

TRENDS IN SCIENCE EDUCATION

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R. A. Campbell

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* F O R W O R D *

Science, the study of which originated as the intellectual hobby of some leisured people, has now developed into the conscious effort of man to control his environment. Inquisitiveness and practical gains were the two main motives behind the study of science. Its manifold applications to industries, commerce, agriculture, food, sanitation and health and transport and communications have practically changed the very ways of human living. Though this marvellous change is due to the applied sciences it should be remembered that those applications were made possible only by the disinterested pursuits of many pure scientists. This realisation has led the public to cherish greater interest in science and science education.

The potentiality of science has so much developed during the last fifty years, that every field of human activities is pervaded by its impact. This impact has begun to revolutionise human civilisation on a line of its own. But the giant strength it has acquired, threatens every now and then, the very existence of mankind. Every thinker at present, is deeply perplexed over the possibility of the total destruction of human civilization as a result of directing the enormous power of science in inhuman channels. Though science has blessed man with plenty of benefits it can lend its power for his destruction as well. So, science is blandishing before us as a double-edged sword. Yet, science has come to stay. Its impact on life cannot be prevented. Its potentiality, both as a knowledge and as

a power to action, has ensured the progress of mankind. But no one can forget the havoc it caused during the last two wars. How are we to avert this situation? The intellect of man that created the weapon, should also enable him to evolve the requisite prudence, skill and will power to use it in the greater interest of mankind. Then only it will be possible to avert the inevitable triumph of the destructive potentiality of science.

It is universally realised that human thoughts have not progressed at the same speed as science and technology. This uneven progress of mankind has been responsible for this potential threat to civilisation. Thus the world is witnessing to-day, a race between civilisation and catastrophe. A conscious effort on the part of man has yet to take place to avert the triumph of the latter. In the history of human civilisation, never was there a greater challenge to our intellect! In all such critical moments the sovereign remedy is to be sought through education. In other words, a search into, and a reorganisation of education should follow. Education so organised, shall aim not merely at the development of our children's ability to control nature, but also at the development^{of} prudence, skill and will power to use it in the better interest of mankind. In other words, the human side of science has to be given its due importance in our science programme in schools and colleges. Such a programme of science cannot operate when calculated doses of information are imparted through the 'tricks of the trade'. Rather, we have to evolve a total programme that ensures the development of a true scientific personality in our children. Humanity, consisting of such men and women, will be able, not only to control nature but also to control themselves and their dealings. It is such

men and women that the new order of society envisages for this age of industrial civilisation.

The challenge to our intellect is a direct challenge to our education. It has to reorient and reorganise itself such as to meet the new demand. While reorganising the science programme, the first problem we have to face is 'Why science for mankind ?' This is a problem primarily, for the philosophers and thinkers. Secondly, it is a problem for administrators and teachers. The latter will have to depend on the former both for guidance and for inspiration on this point. India which is in a transition from the agrarian to the industrial civilisation, has determined to go ahead with the industrialisation of the country. It has also resolved to evolve a society based on science and technology. At the same time it has made it clear that the achievement of science should be only for the good of mankind. This national policy, of course, should fully reflect in our educational system, particularly, in the organisation of scientific and technical education. We have to step up our industries. This depends upon our ability to expand the provision and scope of technical education. This demands in its turn, the organisation of a continuous programme of science education from the primary to the University level on one hand, and to the social and adult education level on the other.

The second problem that faces the country is 'In what form to teach science ?' This is mainly the problem for the thinkers, administrators and educators. The country is proceeding according to plan, to extend the scope of, and the provision for scientific and technical education. This is only one aspect of the problem.

The other aspect is the human side of science education. Our science education will have to include all those items that can inculcate in the minds of children, an appreciation of the human endeavour underlying the development of science and a realisation of the fact that there is plenty of scope in science, for the worship of Beauty, Truth and Power. These are the highest goals that the best of humanities can aim at. Keeping these principles in view we have to reorient our science curriculum. This is an essential reorganisation to take place, particularly, at the post-graduate, technical and professional levels of science education. It is this human aspect of science that we have to supplement to ensure a science programme suited to our culture pattern, and which can ensure the harmonious growth of our thoughts and civilisation.

The third problem that faces us is 'In what ways to teach science ?' This is a problem related more to the means rather than to the goal, and as such, our thinkers and administrators are not so much concerned about it. It is mainly a problem to the educational institutions and teachers as it is their responsibility to work in such a way as to realise the goal before them. The technique of merely imparting the facts of science, should so evolve as to ensure the development of a true scientific personality in our children. This technique of teaching should be adopted not merely in the cultural colleges but also in the professional and technical institutions. The main features of such technique should be so designed as to ensure the realisation of some of the nobler objectives of science instruction which are practically neglected at present.

It therefore, becomes the responsibility of educationists to reorient the science programme such as to supplement the human aspect that is glaringly absent at present. Our industry and technology are rapidly developing to keep pace with our expanding economy. It becomes inevitable to reorganise and strengthen scientific and technical education in the country. It is gratifying to note that the Government of India have declared their policy to assist science education in all its forms as envisaged in their recent statement before both Houses of Parliament. Meanwhile, it is for the science teachers and educators to evolve suitable science programmes, techniques of teaching, reading materials and other aspects connected with science education.

It is disheartening to note that though science is being taught in this country for nearly a century, not many books on 'Science Education' have been published. Even those few books that are published are either restricted in their scope or out of date in their contents. Hence, it is but a felt need that good literature on science teaching should be published not merely in English and Hindi, but also in all the regional languages of India. Then only the teachers and supervisors will have adequate guidance, philosophy and the knowledge of technique with regard to science education.

This book is the result of my long-felt desire to contribute towards the improvement of science education in our country. I have been actively associating myself, for nearly a quarter of a century, with science teaching at different grades of instruction and with the work of training science teachers. It is but natural,

if my personal experience would go to colour the contents of this volume. Meanwhile I had the opportunity of studying science education in U.K. for a year as a special student at the University of Bristol. I had also the good fortune of associating myself with some of the science educators of America, either as a student or as a collaborator. The whole experience of mine, from whatever source I might have gained, has been used in shaping the contents of this volume.

In this volume, by "Science Education" I connote a continuous science programme from childhood to manhood. The word 'Trend' is used to indicate common modes of practice in science education as well as those modes that are observed to be in a process of positive development in apparent directions. An attempt is made to locate the trends in science education as observed and observable in some of the progressive countries of the world. The location of the trends is associated generally, with an assessment of their potentiality and an interpretation of those trends in the light of suitability and feasibility of their implementation in Indian Schools and Colleges.

This book is intended to serve as a source book for students of post-graduate studies in science education and as a guide book to science teachers, educators and teachers under training.

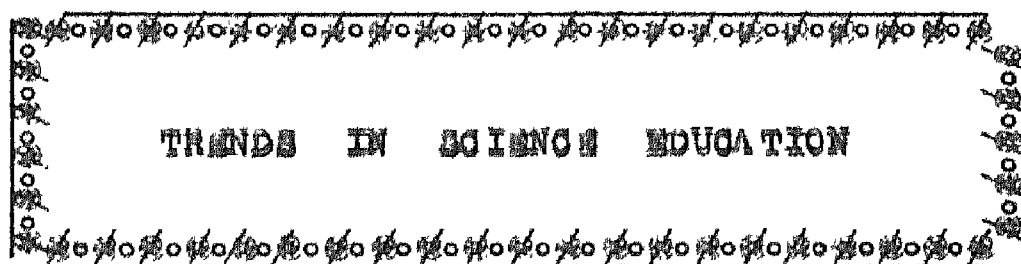
I am deeply indebted to a number of Institutions, Science Educators, Science teachers, Research workers and friends for their valuable assistance in preparing this book. I have derived from them, both information and inspiration needed for this work. As

far as possible the sources from which the materials are used are quoted in the body of the text itself.

I trust this book will contribute, something at least, for fostering and strengthening science education in India.

1.12.1958.

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NOTES ON TRENDS IN SCIENCE EDUCATION

CHAPTER I
I N T R O D U C T I O N

The Purpose, Scope and Technique of the
Study

After the achievement of independence India is carrying on large scale experimentation in the political, social and economic fields. Along with the emergence of freedom a number of national problems arose and awaited serious consideration. There was acute shortage of food; the per capita income was very low; the percentage of literacy had to be raised and the disparity between the poor and the rich had to be eliminated. At the outset, the nation resolved to evolve a socialistic pattern of society through a democratic technology. It was decided to improve the social and economic position of the nation through a series of periodical plans. The first five year plan was launched in 1951. Since the nation was feeling an acute shortage of food, achievement of self-sufficiency in food received priority in the first five year plan. In addition to the extension and development of the existing industries, extensive irrigation works and river valley projects were undertaken and completed. Huge factories for the manufacture of fertilisers were started. These projects helped the nation to achieve self-sufficiency in food to some extent. Being encouraged by the success of the first five year plan the country decided to launch a second five year plan to solve other problems. The gravest of them all was the poor per capita income and the consequent low standard of living in the case of the majority of people. India did not stoop to the communistic technology of pulling down the rich to push up the poor. It rather, resolved to follow a peaceful constructive technique to solve those

problems. So, extension of educational facilities and the increased provision for the industrial opportunity were considered to work miracles in raising the per capita income and subsequent standard of living. So, among other things, industrialisation and education received priority in the periodical plans.

Any plan for the industrialisation of a country should take into account the need for organising the three interrelated types of industries. They are (1) the heavy industries, such as factories to manufacture various kinds of machines, power projects and metallurgical operations etc., (2) the light industries which manufacture commodities, required for the nation and (3) the transport and communications to facilitate distribution of manufactured products. Though India had all the above three types of industries for a number of decades, it depended upon other countries for heavy machinery and a number of manufactured goods. It was essential to achieve independence in this field also. So, a number of heavy industries have been included in the second five year plan, which is now in progress.

The sources of energy, the availability of raw materials and the man-power to run the industries are the three factors that control^{the} success of the industrial economy of any country. Naturally, any plan for the industrialisation of the country should make provision for starting the hydroelectric and other power projects, for harnessing natural resources-mineral, geological and biological, and for training the man-power to run the industries. No doubt, a proper and well planned organisation of various projects is also

a contributory factor. Moreover India has adopted a policy of mixed economy for the industrial field. Certain fields of industry are entrusted to the private sector; other fields are reserved for the Public Sector. The latter is not to compete with the former. Rather, the public sector tackles those fields normally not accessible to private sector. Thus the two sectors work in close co-ordination to form the two wheels of the national economy.

In the second five year plan, provision has been made for the starting of new power projects, for an intensive survey of natural resources and for the training of suitable man-power. It is evident that there is need for three types of man-power for the success of the industries. Firstly, we should have technologists of all types to design and control the quality of the output; secondly, there should be requisite number of technicians to keep up the industrial plant; thirdly, there is need for skilled workers who are directly responsible for the quantity of output. Hence provision for the training of these three types of man-power is an essential factor in the industrial plan.

The advent of industrialisation will change the entire structure of the society. The individual should fit into a new order of society manned by science and technology. Naturally every individual who has to live in that industrial society should have such an education that enables him to understand and appreciate the role of science in shaping the structure of social and economic aspects of the new age. Such an individual with a scientific

outlook and with a respect for scientific method can live as a successful citizen of an industrial civilisation.

Hence, both for preparing the nation to adapt to an industrial civilisation and for getting proper man-power to run the industries, science education naturally demands priority in our school programme. For this purpose the architects of the educational plan would organise a system of science teaching from the beginning of the primary school. No doubt, the work of training technologists and technicians does not belong to the primary or the secondary schools. But undoubtedly, a foundation for such a training is to be laid in those institutions. Though the training of those personnel naturally belongs to the technical institutions, the problem can be better tackled at the primary and the secondary school stages. It is possible to give a definite bias at the end of the secondary school to ensure requisite number of personnel for the industries, within the accepted frame work of a general or liberal education. Hence, it becomes clear that both for the industrial requirements and for the creation of a rational society, it is essential to provide a continuous science experience from the primary school onwards.

Realising the need for improving science teaching at the various grades of instruction in our country, the Government of India organised a Science Teachers' Project. I was deputed to the United Kingdom to study science education in that country, under the Technical Co-operation Scheme. I joined as a regular student at the University of Bristol and worked under the guidance of the University Department of Education. Other science departments of

of the University and the Bristol Institute of Education also co-operated with the Department of Education in organising the training programme. In addition, training facilities were provided by other English and Scottish Universities and the various Educational Committees of that country. Other institutions of the country connected with the advancement of Science Education including the British Broadcasting Corporation, were also selected to provide particular training. The course extended over the whole of the academic year, 1956-1957.

I had therefore, the opportunity to observe the trends in science education in England and Scotland and compare the same with the trends in other countries. The newer trends that I noticed there, prompted me to make this comparative study and to suggest means and methods that could contribute towards the improvement of science education in India.

Purpose and Scope of the Study:

The purpose of this study is to examine the present position of science education in India and to assess some of the newer trends in the field, as observed in some of the progressive countries of the world, like U.K. and U.S.A. An attempt is also made to interpret those trends with a view to investigate how far and to what extent they can be implemented in Indian institutions. The term 'Trend' is used to mean those features that have taken definite shape as well as those that are taking shape in a positive direction. 'Science Education' is used to include science programme in schools and Colleges, post-graduate courses, further educational institutions, professional

and technical courses, teacher education courses and social and adult education work.

Technique Employed:

Schools and Training Colleges and a number of other types of institutions were visited and the programme of science education including the training of science teachers, was studied, some times staying for more than a week in each of the institutions, for the purpose. To have a correct estimate of the British science education the institutions selected for study, included those that were situated in the different parts of the United Kingdom. After studying science programme in the institutions, the various new features were located and their value was discussed both with the teachers and the heads of the concerned institutions. Those features were later, discussed again with the University science experts and the staff of the Training Colleges. By this technique an estimate of the new features in science teaching was recorded. They were compared with similar trends observable in U.S.A. Later, attempts were made to find out which of those new features and to what extent, can be implemented in our own country. Those particular features take the form of concrete recommendations which are included in the last chapter.

Institutions visited in U.K. for studying Science Programme:

A statement showing the number and types of schools, colleges and other institutions studied and the particular special feature or features observed in those schools, colleges and institutions:

Type of Institution visited.	No. of Institu- tions visited.	Special features observed.
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1. Primary Schools.

3

Nature Study - Its contents, teaching technique and scope.

2. Modern Schools - Secondary	6	Practical approach to the syllabus and adapting to the varying ability and interests of the children.
3. Technical Schools - Secondary	5	The problem of specialisation - General Science Course and emphasis on one or the other aspect of science.
4. Grammar School - Secondary	13	Science for non-science specialists-specialisation. Advanced courses in the VI Form. The examinations-correlated activities.
5. Comprehensive Schools	2	Adapting the basic syllabus to different abilities, interests and needs.
6. Bilateral Schools - Secondary	1	-do-
7. Multilateral Schools - Secondary	1	-do-
8. Domestic Schools - Secondary	1	Organisation of working Syllabus
9. Public Schools - Secondary	2	The rigour of the method - the Science Clubs and Natural History Societies - Science for varying age-groups and abilities.
10. County College at York.	1	Remedial Coaching. Practical Approach to Science Teaching.
11. 2 Year Training Colleges	3	Training of Science Teachers - Practice Teaching.
12. 3 Year Training Colleges	3	Science Teachers' Training - The 3rd Year Science Course.
13. Youth Centres: Extra Mural Lectures Workers Education Societies	2 2 2	Science in Adult and Social Education.
14. Colleges of technology	2	Training of Specialists - Science methodology.
15. British Broadcasting Station at London		The School Science Broadcast programme.
16. Corporation Museums:	3	School Science Programme.
17. Zoos:	2	-do-

18. London County Council's Text Book Library Science Film Library Library of Apparatus.	1	Trends in the preparation of science text books - teaching aids and a Central Organisation to supply them to schools.
19. H.M.'s. Inspectors - The Secondary School full Inspection.	1	Central leadership for the schools - guidance to teachers - Inspection of secondary school science programme.
20. Science Masters' Association Annual Conference.	2	The work of the professional bodies.
21. Science Textbook Exhibition	1	New trends in the preparation of science text books.
22. Exhibition of Scientific apparatus at Cambridge.	1	New apparatus and appliances for teaching science.
23. Seminars:	5	
i.Science Education for the Gifted.		Different features of science education.
ii.Science Curriculum		
iii.Science in Technical Education.		
iv.Aims of General Science		
v.Building a Science Curriculum		
24. University Departments of Science: (Bristol, Cambridge, North Staffordshire, etc.)	3	Science course in the Universities.
25. University Departments of Education: London, Bristol, Edinburgh, Glasgow, and North Staffordshire).	5	Special features in the training of science teachers.

Details regarding the Sources of Experience obtained in U.K.

1. A special lecture course was organised by the University Department on Science Education - its principles and practice.

2. Similar lectures on particular aspects of science education were arranged by the Institute of Education and the various science departments of the University of Bristol.

3. Special tutorial classes were arranged. The science teaching

specialists of the Universities of Bristol and London and the science methodologists of the English and Scottish Universities helped me to have a correct and clear picture of some aspects of science teaching in that country.

4. Regular and periodical tutorial classes were arranged by Mr. Roger Wilson, Professor of Education, who was in charge of our training course. Particular attention was devoted in these classes, to consider the observed special features of English science teaching and to what extent they could be implemented in our own country.

5. I discussed the various aspects of science education with some of the eminent persons in the field. Professor Paul, Professor Wick, Professor Pheasant, Professor Mills and others were some of these educationists with whom I discussed the above problems. Those discussions were arranged by the Bristol University, as part of our training programme.

6. Study visits to various types of Secondary schools, Primary Schools and other institutions devoted for further education were also arranged. This programme was spread over the whole year as part of the course, approved by the Department of Education. This was intended to study the various new features in science teaching in the schools of United Kingdom. To ensure the knowledge of a good cross section of the nature of science education in the country, visits were spread over the various parts of the United Kingdom. Several days were continuously devoted to study science teaching in Grammar, Technical and Modern Secondary Schools. The following aspects of science programme were studied during the course of the visits:

1. Courses of Studies in Science.
2. Adaptation of the Basic Syllabus to the varying abilities, needs and interests of children.
3. Laboratory organisation and management.
4. The plan of the Science Class Room.
5. The Science text-books in use.
6. Use of optical and other teaching aids.
7. Correction of pupils' practical records.
8. Activities connected with Science Education.
9. Assessment of pupils' achievement in science.
10. The ^{prescribed} courses and standards set by various examining bodies.

7. Discussions with the Headmasters and the staff of the science department were held in every school at the end of the study to discuss certain things arising out of our observation and to get certain doubts clarified.

8. Participation in the discussion classes on the lesson plan prepared by the post-graduate pupils of the department, was a special feature of this study programme. This was particularly interesting since it was a new feature to our Post-graduate teachers' training institutions.

9. A workshop was organised to provide facilities to us in the preparation and use of teaching aids. Provision was also made to provide training in the use of newer optical aids.

10. Another work-shop was organised to train in the art of evolving working syllabus in science for the various grades of

secondary schools. An expert science teacher was deputed to help me in the matter.

11. I was deputed to the Bristol College of Technology for an intensive training in the Laboratory art craft for a period of one month. The College provided a course of training in the Laboratory equipment and management, glass welding, glass blowing, glass bending, metal and wood work, chemical analysis technique, photostat process and other photographic art-craft, micropreparation and staining techniques, etc. This course included both lecture and practical work.

12. Study visits to the different Departments of Science in the various Universities of England and Scotland were special feature of this course. Opportunities were provided to study science course in the various Universities and to know the standard they fix up for admission. I specially made a thorough study of the science education in the new University of Northstaffordshire, as it was a four year University with a foundational first year. As science for general education, was so integrated with the general courses of studies, particular attention was paid to observe the educational philosophy of the new University in general, and the place it has given to science education in particular.

13. Two Boarding schools were visited, the Public school at Winchester and the Bootham School at York. A week was spent in each of the above to study science programme in those two boarding schools. The Science Club, the Natural History Society and the particular

coaching provided to backward pupils were specially interesting.

14. I was deputed to London University for one month to study the training of science teachers in the University Institute of Education. I attended special lectures organised for the purpose. I noticed that the Teachers' Centres organised by the Institute and by some of the affiliated Colleges were doing very good work to train the science teachers in service.

15. The London County Council has organised a text-book library, a film library and a library of apparatus and appliances. I spent a few days over studying the purpose, organisation and facilities provided by those Institutions to the science teachers in London. I was particularly interested with a few science text-books that were placed there. They are all books that are reviewed and approved for the school use.

16. School Science Broadcasting is a special feature of science education in English and Scottish Schools. I was fortunate to go over to the British Broadcasting Corporation at London, to study the science broadcasting programmes. I studied various aspects of its school science programme - preparation and standardising of the script and its actual broadcast. I was particularly interested to find a good coordination between the station and the schools.

17. Visits to Science Exhibitions were also arranged. The Science Exhibition at Cambridge organised by the Science Masters' Association was particularly interesting. I examined the latest apparatus and appliances exhibited by various manufacturing firms

and the science text books and general books published by the Science Masters' Association and other publishers.

Things of scientific interests were also examined in the British museum at London and in the museums at York, Bristol and Cambridge.

18. Visits to University Departments of Education, were also organised. I was deputed to study the work of training science teachers at the Universities of London, Bristol, Cambridge, Oxford, Northstaffordshire, Edinburgh and Glasgow. These Universities were selected because of the particular special features for which they were well known.

19. Two weeks were devoted for the study of science programme and methods of training science teachers in the two year Teachers' Training Colleges. I studied the work in St.John's Training College and in St.Mary's Training College at Cheltenham and in the Training College at York. The third year science course that they had already introduced was particularly interesting.

20. Visits to some of the science laboratories were also organised. I visited the various science departments of the Universities of Cambridge, Bristol, Northstaffordshire, Edinburgh and London.

21. Participation in the activities of the professional bodies was a special feature of the study. I participated in the Seminar organised by the S.M.A. at Bristol on the Teaching of Science to Abler Children; later, I participated in the proceedings of the Annual Session of the S.M.A. held at Cambridge.

22. I was deputed to study the work of Her Majesty's Inspectors (Science Section). I studied how the inspection of the Secondary School Science Department is being conducted by them, in the Yorkshire Schools.

23. Every item in the training programme was accompanied by academic discussion which formed a very useful follow-up work. Professor Roger Wilson took particular care and interest in assessing the value of my programme and in discussing various aspects of the observations made.

24. The members of the staff of the Department of Education periodically assigned to me books, articles and important reports to study and ^{to} report, and even to sit for discussions.

Analysis of Experience:

The above study involved collecting data from various types of secondary schools, colleges and other further educational institutions with respect to science programme. Though I was attached to the Bristol University, I had to study in other Universities also. The nature and experience embraced almost, all aspects of science education. Hence it is essential to analyse the same into particular types of experience. I find it convenient to analyse the same under the following heads:

1. Science and its role in the modern social life.
2. The importance of science as a subject of General Education.
3. The objectives of teaching science.
4. The Science Course - Basic Syllabus and its adaptation.
5. The organisation of science curriculum.
6. General and special science courses.

7. Allocation of time for science instruction.
8. Theory and Practice in the Secondary school science programme.
9. Laboratory and lecture room.
10. The science store room - method of arranging the apparatus.
11. The teaching technique.
12. Demonstration of experiments.
13. Teaching aids.
14. Textbooks.
15. Notes-taking by pupils.
16. Use of Community resources.
17. Science course for the gifted.
18. Remedial programme for the backward.
19. Individual attention.
20. The school science broad-cast and television programmes.
21. The School Science Club.
22. Natural History Programme.
23. School Science Museum.
24. Science in newspapers, journals and other periodicals.
25. Testing achievement in science - tests and examinations.
26. Standardised tests.
27. Science teachers and their qualifications.
28. The recruitment of science teachers.
29. Organisation and working of science teachers' associations.
30. Training of science teachers.
31. In-service training facilities for teachers.
32. Science teachers and their academic contract.
33. Science in the technical secondary schools.
34. Science in social education.

35. Science subject-inspectors and advisers.

36. Science teaching in secondary schools and in the institutions for higher studies.

In the accompanying chapters, devoted for study of the trends in science education, I have made use of the varied types of experiences which I gained during my stay in the above country. In addition, I have also utilised my long experience as an author of science textbooks, as a science teacher, as a science methodologist and as the Professor of Education. Some of the new features which I considered as novel, are elaborately dealt with in separate chapters. Others are included in the list of suggestions or recommendations in the last chapter.

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CHAPTER II

The Increasing Impact of Science on our Social Life

Though India has been an agricultural country from the very beginning, attempts are being made from the last hundred years to develop various types of industries. One cannot but notice that a greater number of industries are being started all over the country in recent years. Attempts are also being made to mechanise agriculture to the extent the nature of our agricultural lands permits. Further, the benefits of science have reached even the remotest parts of the country and thus have commenced to revolutionise the life of the people. Old notions are giving place for rational and realistic views. Thus we notice the gradual transformation of the country from an agrarian type ~~civilisation~~ to an industrial type of civilisation. In conformity with these changes, India has evolved into a republic and has launched the biggest experimentation in Democratic way of living. Such a country with its developing scientific and democratic ways of living, will have naturally to forge a policy to strengthen national economy based on scientific industries.

After the advent of freedom India has decided to improve the life of the people in the social, economic and other fields, through a series of periodical plans. After the country became free we had to face a number of problems. Among them the most serious one was that of food. The first five year plan was launched in 1951 and its main purpose was to achieve self-sufficiency in Food. In addition to the launching of many other nation-building schemes,

during the period of the first plan, extension and development of irrigation facilities, construction of river valley projects, starting of huge fertilizer factories, etc., were undertaken. As a result of the determined effort of the nation the country was able to become self sufficient in food to a great extent. During the same period a number of new factories were started; new schemes to extend educational facilities were also undertaken; plans were prepared to reorganise the educational system keeping in view the changed position of the nation. The success achieved in the first plan encouraged the nation to launch a Second Five Year Plan to tackle other national problems. India inspite of its huge area and large population had to depend on other countries for a number of essential manufactured goods, particularly the machineries. Further, the per capita income of the people was substantially low. In recent days the country declared its determination to improve the per capita income and subsequently the standard of living. With its declared policy of re-constructing the society on a Socialistic pattern, the fate of the common man had to be improved. Plans to develop agriculture and industry were the twin tools to realise this aspiration.

Though we are trying to industrialise the country we cannot forget that the major occupation of the people is agriculture and the huge population has to depend upon its own work in the field. Hence any scheme to improve the fate of the country should include plans for the development of agriculture. No doubt, our agricultural operation is to a great extent at present, handicapped by individual ownership of small pieces of lands and the age old method of agriculture

To overcome these difficulties, the country has decided to introduce collective and cooperative farming. This would certainly facilitate improving the agricultural products both in quantity and in quality by the application of mechanised and improved techniques in the agricultural operations.

Side by side with the plan for the institution of collective farming and mechanised agricultural operations, the country is fast ahead with its scheme of industrialisation. The second five year plan is devoted to the organisation of heavy industries in addition to a number of other nation-building activities. Industries in any country resolve into three categories: 1. Heavy industries which include the starting of power projects, large scale metallurgical operations and the manufacture of machineries; 2. Light industries to manufacture commodities for the people. 3. Organisation and maintenance of transport and communications for improving the means of travel, transaction and transporting from one part of the country to the other. Evidently any good plan for the industrialisation of the country should provide priority for the heavy industries, as the success of the second and the subsequent plans depends largely, on the completion of the first plan.

No doubt, there existed in the country all the above three types of industries even before the advent of freedom. But, they were too inadequate primarily, to meet the demands of the country with regard to the production of commodities and secondarily, to strengthen the national economy. Added to these the industries were started with no definite plan and regard to the national requirement. The few

existing industries were manned either by foreign companies or by foreign technicians. Hence the country had to provide a very bold leadership in the field of reorganising the industries on a scientific and well planned line.

Any plan for the industrialisation of a country should pay attention to three important factors that go to make the plan a success. The plan should make provision for the development of hydro-electric and other power projects which form the sources of energy to run the industries. Secondly, it has to conduct a survey of national resources, mineral, biological and geological and make provision for the development of those industries that make the raw materials available for the industries. Thirdly, it has to organise educational ^{and} training facilities to produce adequate man-power suited to run the industries, maintaining both the quality and the quantity of production.

Though agriculture is our single big enterprise, that alone cannot contribute for strengthening our national economy; we have to reorganise the nation's economy on an industrial line. Then only our economy will be placed on modern footing. Some countries are leaving the industries to the private agencies, as in America; in other countries they are maintained by the State Governments as in Russia. India is following a mixed policy. The present policy of the Government of India is to have a mixed economy in the country, leaving certain industries and industrial sections to private ownership and management, and to nationalise some of the industries. Here it is essential to note that ^{the} Public or the Government sector is not

working as a competitor with the private sector. Rather the, Government is retaining those industries for the public sector, which cannot be run by the private sector. In other words, the public sector is mainly intended to supplement the work of the private sector. Hence, India depends upon both the public and the private enterprises in the task of industrialisation. Whether it is public sector or the private sector, the success depends upon the above said three cardinal factors. Naturally, it becomes the responsibility of the state to provide those facilities, all of which depend in turn, on an efficient programme of scientific and technical education in the country at different grades and levels of instruction.

Regarding the technical man-power required for the industries, one can distinguish three categories of people. Firstly, there is need for technologists for designing newer features in every industry and on them depends the progress of the industry. Secondly, there is need for technicians for upkeeping and running the normal work of the industry. The quality of production depends to a great extent on the type of work they do. Lastly, there is need for skilled workers who actually work with the machines and on them depends the quantity of production. Though we require more of the third type of men, the other two types of workers are also necessary. It is essential to organise technical and vocational institutions at three distinct levels to produce the above three types of man-power. Even if automation were to be introduced sooner or later, the above three types of man-power will be essential for industries. It becomes evident, therefore, that any scheme for the industrialisation of a country should also provide for training the requisite technical man-power for

the industries.

Technical education no doubt, is of different types. Each industry requires specially trained staff. In fact, the best kind of training is that which is provided in the particular industry itself. Yet, it is usual to get those personnel trained in the particular technical or vocational institutions. In India has to-day, a number of such institutions at different levels to train the various types of personnel for the growing industries of the country. Their mere existence may not ensure properly trained workers, technicians and technologists in sufficient number. Those institutions must be scientifically organised, distributed with due regard to the regional requirements and should be suitably fed. Whatever the field of vocational or the technical education it may be, its success depends on the type of science teaching that students can have in their school days. It is on account of this that the White paper on Technical Education published in 1957 by the British Government, states that "the success of our industries depends largely upon the type of science programme, the schools provide". Therefore it becomes clear that the problem of producing requisite man-power for our industries, should be tackled at the secondary and even at the primary school level. Though schools are mainly intended for cultural education, the way in which they teach certain subjects largely contributes for laying the foundation for the production of desirable types of man-power for the industries. The most intimately connected subject to the nations industries is Science. Hence the industrial development of a country is naturally, though indirectly, connected with the type of science instruction provided in the primary and secondary schools. The success of science teaching in the school depends upon the course contents, the teaching technique, provision for experimentation and the mode of approach. Hence, this in turn, demands an effective science education

at the University and a well organised training programme for our science teachers. As part of the reorganisation scheme in the field of education, the above needs are being attended to. Meanwhile efforts should also be made to send our teachers and educationaists to other progressive countries, to study the position of science education and the progress of science.

There is still another factor that stresses the need for improving our school science programmes. India to-day, is in a process of rapid change from the agrarian to the industrial civilisation. In the earlier civilisation superstition, blind faith and irrational thinking were rampant and even upheld by traditions. But such things will be incompatible with the industrial civilisation. Industrial society thinks, feels and acts at the rational level, at an impersonal level. Naturally the success of the individual and social life in such a civilisation demands an understanding and appreciation of the ways of the science and the particular role it plays in our life. It evidently means that for the success of our industrial economy the individuals must develop scientific outlook, attitude and spirit. In their every day living, scientific technique should play a large role. This is possible if our general education programme can provide in addition to other things, a very effective science instruction in schools and colleges. Then, our schools can help to a great extent, the easy transition that is taking place at present from the agrarian to an industrial type of civilisation.

The present transition to an industrial civilisation further demands on the part of the individuals and the leaders of the country,

CHAPTER III

PRESENT POSITION EXAMINED

1. Early Science Teaching in India:

The early decades of the nineteenth century witnessed a series of controversies in the field of education. Those controversies centred mainly round the type of education and the medium of instruction to be adopted for the whole of India. The Orientalists supported the idea that the oriental learning should be preserved and promoted and that the medium of instruction should be Indian languages. On the other hand, the occidentalists upheld the idea that India should introduce Western knowledge like English literature and science in the schools and the medium of instruction should be English. The views of both the parties were placed before Lord Macaulay, the then Legal Advisor to the Government of India. He emphatically rejected the arguments of the orientalists and supported the idea of spreading Western Education in India through English. Macaulay submitted his views in his famous Minute of 1835 and the same was endorsed by Lord William Bentinck who was the Governor General. In his proclamation dated seventh, March, 1835, Bentinck passed the following orders in addition to others:-¹

" His Lordship-in-Council is of opinion that the great object of the English Government ought to be the promotion of European literature and science among the natives of India; and that all the funds appropriated for the purpose of education would be best employed on English Education alone".

Further, the proclamation approved Macaulay's idea of using English as the medium of instruction in schools in the following words:²

"His Lordship-in-Council directs that all the funds which these reforms will leave at the disposal of the Committee be henceforth employed in imparting to the native population a knowledge of English literature and Science through the medium of the English language".

The above proclamation did make a turning point in the history of Indian Education. It defined the aim and type of education. It declared in a very clear and emphatic language that the avowed objective of the country was the promotion of Western arts and sciences.

Though a good number of criticisms could be levelled against Macaulay's advice, he cannot be blamed for certain aspects of it. He was certainly right in his conviction that the virile civilisation of the West was necessary for rejuvenating Indian culture. He never dreamt that his minute would have such large implications as to change the very face of Indian education. Sound judgement will indicate that after all, Macaulay's Western learning has done good to India and better results have been achieved through his bold policy than it would have been possible through the half-hearted attempts of the orientalist. The new system of education brought us into contact with the scientific knowledge and researches of the Western Countries. In this respect the seed sown by him in 1835 has certainly produced a crop, far richer than that expected by the sower. The following decades witnessed a changing scene in the Indian Education. In the place of a scheme of spiritual training a system of education endorsing the spirit and rigour of the Western sciences was being introduced.

Lord Auckland who succeeded William Bentinck as Governor

General, pushed his educational policy forward with the same zeal and tenacity. He took measures for the expansion of education. Since he, like Bentinck and Macaulay, believed in the filtration theory, tried to communicate through the medium of English a complete education in European literature, philosophy and science to the greatest number of students who may be accepted to receive at his hand. He was instrumental in starting some Central Colleges at Decca, Patna, Banaras, Allahabad, Agra, Delhi and Bareilly. By that time a good number of state schools were being organised with science as one of the subjects of study. He intended those pupils coming from the state schools, should continue to study science and other western knowledges in those colleges. After 1833, the English Missions went on starting more and more schools and colleges in which they provided Western knowledges as subjects of study. But, for a long time to come, elementary schools were not started by the state; and certain foreign missions with the interest of converting Indians into Christianity, were however, running a number of schools all over the country. But they were not in sufficient number. Many people did not like to send their children to those schools on the fear of conversion. Lord Hardinge during the middle of last century, established 107 vernacular schools. But Science was not a subject of study in those elementary schools. But generally education of the masses was neglected; and even in those few state schools and private schools, science was not a subject to be studied in any form. This was due to the fact that the Government believed in the filtration theory.

Following the recommendation made in the Wood's Despatch of 1854, both state and private secondary schools went on increasing in

number. This also extended the facility for science education in the country. As a result of this, there was a rapid growth of Colleges. The Universities of Calcutta, Bombay and Madras were established in 1857 as examining bodies.

The starting of University and Government Colleges gave impetus for the spread of western education. The Government of India declared that they would prefer for public jobs, candidates with English language and western knowledge. So, there was a huge rush for admission to the institutions.

While the higher education was being extended, the Government did not pay sufficient attention for the expansion of primary education till the last decades of the 19th century.

By that time, the problem of introducing Science in the secondary schools was being seriously considered in the west. By about the middle of 19th Century Herbert Spencer, T.H. Huxley and other champions of science in England, advocated that science should be introduced in the secondary schools. In the latter half of the 19th century science gradually entered into the school curriculum in England. Since English system of education was the model on which Indian system of education was being organised, a little later science was introduced as a subject of study in the secondary schools of India. So science made its entry into the curriculum of the University first, and then into the curriculum of the secondary schools. By about the last decade, all secondary schools in India, included science in one form or the other, as a subject to be studied. But the introduction of science in the elementary schools, in any form, was

much delayed. It is only in the second decade of the present century that efforts were made to introduce nature study in the Elementary schools as one of the subjects to be studied.

2. The Nature of Indian Secondary Schools and the Subjects studied there :-

After the introduction of English as the medium of instruction a variety of schools were started both by the Government and by the private bodies in all of which English was taught as a subject and was used as the medium of instruction. Some of them admitted children at 5+ and others at a much later age. But following the recommendations of the Hartag Committee in the latter half of the 19th Century, the Government took up the responsibility of organising elementary education in the country and defined that all instruction below the secondary schools as elementary. In some states secondary schools admitted pupils at the age of 10+ , and in some other states at the age of 11+ . Generally there were two stages in the secondary schools - the Lower Secondary or Middle school and the higher secondary or High school. In both these schools there was a terminal External examination. The subjects studied were English, Vernacular, History, Geography and Mathematics. In the Middle Schools Hygiene was taught as an optional subject. In the High Schools in addition to the above subjects Elementary Science was also taught. The duration of the secondary school varied from state to state. In other words, the period of secondary education was not clearly defined.

In recent years, it was felt both by the public and by the

educationists, that our secondary education should be reorganised so as to bring about proper coordination with the primary education on the one hand and the University education on the other. The Government of India constituted a Commission to consider the question of reorganising secondary education, under the Chairmanship of Shri Lakshmanaswamy Modaliar in 1953. The Commission after careful consideration of various problems connected with secondary education, submitted its recommendations to reorganise its different aspects. Among other things the Commission recommended the following pattern of reorganisation of education:-³

1. Primary or Junior Basic School - for 4 or 5 years
2. Middle or Senior Basic or Junior
Secondary School - for 3 years
3. Higher Secondary School or
High School - for 4 years
4. University Degree Course - for 3 years

(Page 230 - Report of the Secondary Education Commission,
1953)

The above recommendation has formed the basis on which the general pattern of reorganisation of education is taking place in the different states of India. In some states like Bombay, Utterpradesh, Mysore, etc. the Pre-University education is being organised into two stages only - a seven year ~~or~~ primary education followed by a four year ~~or~~ secondary education. Some states are organising the same into three stages - a primary stage of four or five years, a middle stage of three years and a secondary stage of four years. Whatever the pattern of organisation it may be, as per the suggestion of the Commission, secondary education should cover the age-groups between 11 and 17.

The total period of education before getting the University Degree will therefore, amount to fifteen years. In some states, it is reduced to 14 by curtailing the duration of primary education by one year. In the proposed 4 year course of secondary education the last year represents the old junior intermediate course which was part of the University education before. It may be therefore, said that the public examination at the end of the four year secondary education is equivalent to the 'A' level G.C.E. examination of U.K.

A draft curriculum in Science as ⁱⁿ another subjects, has been prepared by the Central Ministry of Education. But education in India as in U.S.A., is purely a state subject. Therefore, each state is preparing to adapt the central curriculum in science in accordance with the local needs and local environment. Some states have already given effect to the new curriculum. Science is introduced from the beginning of the primary school. The old 'Nature Study' of the Primary school is replaced by general science. The same sort of science course for all is continued in the secondary schools so that there may be continuous science experience throughout.

New India has launched the second five year plan shortly after completing the first. The success of the plan depends to a great extent, on the availability of technicians and other skilled man-power. To this end it has been realised, that science programme in the schools should be organised on modern lines. Hence, both the Central and the State Governments have taken lot of care to reorganise Science curriculum in a suitable way. In reality, the subject of

science is given a very important place in the school curriculum so that rapid industrialisation may be facilitated.

3. Courses of Studies in Science:

The new general science course has already been introduced in some states. Wherever it is introduced, the subject is organised around 5 or 6 major topics related to life. This arrangement of matter which begins with the science course at the primary school, continues in the secondary school. The important topics around which the science curriculum is built are the following:⁴

1. The food we eat
2. The air we breathe
3. The water we drink
4. Our shelter
5. The Energy
6. The atmosphere around us
7. Transport and communications, etc., etc.

The same topical treatment continues from the first standard to the last. The matter extends concentrically from year to year. In some states the topical arrangement is restricted only to the lower grades of the secondary schools.

To appreciate the science teaching at the secondary school level, it is essential to know a few aspects of the same at the primary school level. The old 'Nature Study' is being abandoned since it is considered to be inadequate to the life of modern children. The general science course, which has taken its place in the primary school curriculum has not become quite popular. The main reason for this is that the primary school teacher does not possess sufficient qualifications to teach

science. Another reason for its poor progress is that no primary school is properly equipped with necessary materials and books. Therefore it is felt that the minimum qualification of primary school teachers is to be raised and the state should provide funds to supply apparatus and appliances to primary schools. Till then, science cannot be taught effectively at that level. Some states are already moving in this direction.

In some states like Mysore where the new general science course is yet to be introduced, the lower secondary school did not include science in its curriculum before. In other states like Madras, Bombay, etc., the lower secondary school is only part of the secondary school and science had already been introduced from the first form onwards. Moreover, in such schools there will be laboratory and adequate equipment. The teachers also possess much higher qualifications. Hence, science teaching is much effective in those states at this level. The courses of studies are organised around some major topics and the subject matter extends in a concentric way from grade to grade.

Before 1925, in a number of secondary schools science curriculum included physics, chemistry and human physiology. After the publication of the Prime Minister Committee report in 1919, in England, (with Sir Arthur J. Thomson in the Chair) schools in India also, reorganised their syllabus in science and included Biology in addition. From that time onwards, the three special branches of science were being taught. The special science course has now begun to give place for general science course. But in reality, physics, chemistry and biology are being separately taught as before.

since the introduction of general science course is a recent event in the history of science teaching in India and some states have yet to implement the new curriculum in their secondary schools, it is better to consider some aspects of our science technique as it existed during the earlier days.

4. Science Programme in Indian Secondary Schools:

The science course generally includes physics, chemistry and biology. In each branch some topics of interest and utility are selected and grouped to form the curriculum. Studies in interest survey and grading of topics have not been undertaken. Hence the arrangement of topics is purely academic in nature. Moreover, the syllabus is dictated to a great extent, by the University experts since all secondary schools coach up to the University examination. But the syllabus is to be built in accordance with the pupils' age, ability, interests and aptitude. Further, the needs of the locality and the nature ^{of} ~~and~~ the environment where the pupils live, are also to be taken into consideration. Until research studies are carried out in these fields, it is not easy to construct a scientific curriculum. The optional science course is divided into theoretical and practical. Physics and chemistry will have provision for pupils' laboratory work. But the same provision does not exist for biology. General biology which includes human physiology also, does not form 1/3 of the general science course. It forms one fourth of the science course (estimated on the basis of marks allotted for each branch of science). Hence biology is looked down as the Cinderella in the domain of science. The step-motherly treatment has made many pupils think that biology is not such an important branch of science. However, this defect will cease to exist when the proposed general science course is introduced.

The practical work in physics and chemistry is intended not for all grades but for the last two grades of the secondary school and that too, only for those who take up science as additional subject. Nowadays, there is a growing tendency among the teachers not to differentiate the subject into practical and theoretical aspects, in the general science course. But it is essential that science course should be practical. If some of the periods at least, are double periods, it is possible to provide some practical activity to the pupils, in addition to the theoretical instruction, and thus the differentiation can be avoided.

Allotment of time for Science:

In the old set up, the amount of time provided for science programme varied from state to state. In the majority of secondary schools, 6 periods of 45 minutes each, were provided for general science in the first year and 3 periods in the remaining years. In the new set up, 4 periods are provided for general science in the first year and 2 or 3 periods in the remaining years. There is a general agitation that this provision should be increased at least, to 4 or 5 periods per week.

Adequate time has been provided for the optional science course. Two single periods and one double period are provided for each of the three branches of science, that go to form the group. That means, 12 periods are provided for the purpose.

5. Science Laboratory - its equipment and management:

The general equipment of the secondary school science laboratory depends upon the type of secondary school - the Government, Board, Municipal or Private secondary schools. These are the four main types of secondary schools. Those secondary schools which are directly managed by the state governments have well equipped laboratories. Municipal or District Board Schools have comparatively poorly equipped

laboratories. In the case of many private aided secondary schools the laboratory equipment is deplorably bad.

Among the science teachers in India there is a notion that they should use only costly complicated apparatus for experiments. Many of them do not try to make the simple apparatus which can be prepared easily. This is mainly due to the facts that they do not have sufficient time to prepare and many of them have not received training in that particular art. There is need for drawing their attention to the importance of using simple home-made apparatus.

A word or two may be said regarding the plan of the school science block. It consists of 3 apartments. The central room is smaller and is used to store apparatus, chemicals and appliances. The one adjacent to it is the lecture demonstration hall. It may have a gallery or not. It may have accommodation for 60 pupils to sit. (though the maximum fixed is 40, it goes upto 60). On the other side of the store room there is the Laboratory. Pupils in batches of 20, 25 or 30 will have to work at a time. There may be 3 or 4 work benches. Usually gas burners are absent. Spirit lamps are to be used. There will be a common sink.

6. The Objectives of Science Teaching:-

Until very recently the purpose of secondary education in India was considered to be mainly to prepare pupils to the University courses, and as such, the courses of studies were purely academic. From the second quarter of this century there has been a reorientation of the purpose of secondary schools. It is stressed more than once, that secondary education must not merely look at the University, but must also care for the majority of pupils who will discontinue after matriculation. This has made us resolve that our secondary schools must provide a complete

education by itself, though it has to cater for the needs of a few pupils who take up research advanced studies in the University. This changed concept of the purpose of secondary education has brought about a change in the objectives of teaching any subject at this level, and particularly so with regard to the teaching of science. Further, this changed objectives of science teaching have influenced to reorganise the science curriculum so as to fit in to the new needs.

An analysis of the general objectives of science teaching indicates that we should primarily take into account that after leaving the school, every pupil must have been equipped with the minimum amount of scientific information, skill, attitudes and appreciations which should form the outcomes of a course of general education. The above objectives may be listed as follows:-

1. Practical aim:- To provide ability to pupils to understand and live harmoniously with their physical, social and material environment.
2. Vocational aim:- To provide ability to learn a trade or take up a job and discharge the same with intelligence and insight, to earn his livelihood.
3. Disciplinary aim:- To train the individual in the correct habits of thinking, doing and behaving which should form the necessary equipment of the personality of a citizen of the scientific age.
4. Cultural aim:- To provide that amount of scientific insight and information which shall form the necessary mental make-up of every individual who would like to appreciate and understand the texture of the industrial civilisation.

Though the above four aims are dominant in the minds of all science teachers, a fifth aim claims the top rank in Indian science teaching. The whole population has endorsed, from times immemorial, a civilisation

state of India secondary education is free. The pupils will have to pay fees. But the fee is not very high. The total fees collected will not be a considerable amount. Hence the school has to depend upon their financial resources. With regard to the state secondary schools there will be fairly adequate funds to equip laboratory with necessary appliances and apparatus. In the case of Municipal, District Board and other private secondary schools the annual grant will be generally insufficient to meet the needs of the laboratory up-keep.

8. Science Teachers and their qualifications:-

The minimum qualification required for a teacher in the lower secondary school is a pass in the matriculation examination, equivalent to the Ordinary Level, General Certificate of Education of U.K. (10' level G.C.E. Examination). The teachers in the upper secondary or the High Schools possess the university degree. Many of the science teachers have studied only two or three branches of science in their degree course. A Biology graduate will have studied Botany, Chemistry and Zoology. A physical science graduate will have studied Physics, Chemistry and Mathematics. In some universities, they can graduate themselves with only two branches of science. In either case, the general equipment of science education at the degree level is not adequate in breadth to teach general science. At present, science is taught in the form of its separate branches. Each teacher is handling his subjects or subject. Some of the teachers are Honours graduates who have specialized only in one branch of science. They are much more incompetent to teach general science. Hence it is felt that new combinations of science subjects should be offered at the University level.

If combination like -

Physical Science (Physics and Chemistry)

Biological Science (Zoology and Botany)

Geological Science

is introduced, it will be possible to get better teachers to handle general science. Such graduates are much more suited to teach general science at the higher level of the secondary school. In the final year of the secondary school, the new set up envisages to teach science in the specialised form. For that purpose it will be necessary to engage graduates who have specialised in Physics, Chemistry or Biology. There is a move to introduce general science as one of the major subjects for B.Sc. degree in some of the Universities.

In connection with the introduction of general science in all the secondary schools of India, it is evident, that the existing science staff cannot be disbanded. Rather, it is necessary to give them adequate training through refresher courses so that they may be able to handle satisfactorily, those topics that are not studied by them at their degree level. Universities may also provide special opportunities for the teachers in service, to qualify themselves to teach general science.

With regard to professional training, many a time, fresh graduates without training in teaching, are employed in the secondary schools; after 6 or 7 years of service they are deputed for training at Government cost. It is felt that some weeks or months of professional training is essential for such freshers. But no systematic training provisions exist at present for such fresh teachers. Whenever science teachers are to be employed it is essential,

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in future at least, to give preference to those who have studied as many branches of science as possible at the degree level so that they may be competent from the academic point of view, to handle general science. It is also essential to appoint as far as possible, teachers who are already trained.

9. The Teaching Technique:-

If the curriculum experts were to say that after all, it is the nature of science curriculum that counts in the realisation of our desired goal, the psychologists claim that the method of instruction plays a larger part. It is however, difficult to repudiate the claim of either of them. Of course, it is not my intention here to enter into the discussion of the above question. It shall form a topic of a separate thesis. Yet it is wise to realise that, inspite of the best of curriculum, the outcomes of instruction will not be satisfactory unless a suitable technique is followed by the teacher. Hence, it is essential to consider in detail the various faces of the class-room technique that is being followed in the secondary school science programme in India.

THEORETICAL ASPECT

So long as there is clear demarcation between theory and practical and separate periods are allotted for each of them in the optional science course, it is necessary to consider the techniques used in the lecture class and laboratory hall separately. However, the unsuitability of differentiating general science course into theory and practical, will be separately considered.

India being a large country it is difficult to expect that there is uniformity in the technique of teaching science. But the popular

method both in the training colleges and in the progressive secondary schools, is the Herbation plan. It may be advisable to mention briefly the main steps of the method.

i. The introductory step: The teacher prepares the minds of the pupils to the ensuing lesson by eliciting certain related experience. If it is a fresh lesson he generally uses a topic of social or human interest as the introduction. If it is a continuation lesson the recapitulation of the salient features of the previous day's lesson will form the introduction. The introduction culminates in the statement of aim. This is generally made by the teacher with the pupils' participation.

ii. The presentation stage: This step which follows the statement of aim is the preliminary exploration of source material. This may take the form of presenting an experiment, a specimen, a model, a chart or a film or a diagram. In any case it forms the main material for the development of the topic. Some times, a series of similar but variable types of experiments may be conducted. Observed facts will be recorded.

iii. The comparison stage: The facts and figures observed or recorded in the previous stage, will be organised so as to facilitate the pupils to seek the underlying principle or rule.

iv. Generalisation stage: In this step the teacher will guide the pupils to state in their own words the principle or the law that is underlying the facts and figures. The teacher may finally treat the wordings and bring it to the proper form.

v. The Application stage: In this stage the teacher makes use of the just then formulated principle or rule to explain certain

situations or to solve some problems. He tries by this means, to test the validity of their generalisation.

This is the popular plan on which the lesson proceeds. In case of biological topics where generalisation will not be necessary or possible, the third and fourth steps may be omitted. Then, the lesson looks like the inductive development of a descriptive topic.

Though the above inductive - deductive line of developing a lesson is really a sound technique there are many details involved in it which may go a long way to make or mar the technique. It is therefore necessary to consider certain special features of the above technique as they are actually being followed.

1. The Principle of "Learning by Doing"

The effectiveness of 'learning by doing' particularly applies to the field of science instruction. For this purpose the subject of science has ample scope and possibilities. Every science topic is an organised knowledge developed primarily, around some experimental activity. If pupils were to be introduced to those activities while teaching science, they will really learn by first hand experience. But this naturally requires time. But the responsibility of the teacher to cover the load of syllabus makes him, many a time, give out to the students much of the knowledge regarding the topic through his talk. This, rather curtails pupils' initiative in the process of learning. Further, it encourages them more to be passive listeners than to be active participants.

The poor laboratory equipment, even with regard to some of the

schools of the metropolitan cities, comes in the way of providing activity to all the pupils of the class. The number of pupils in the class will be as high as 50 or 60. Naturally it becomes very difficult to provide activity to them. They will have to be satisfied with the teachers' demonstration of the experiment. Let us hope for the coming of a time when our schools will have adequate apparatus and appliances to provide activities to all the children in the class. Let us also hope for a time when we can have 20 or 25 pupils only in a science class!

ii. The Problem solving attitude

Any good method of teaching science should create, to start with, in the minds of the pupils, the desire to inquire into things. This inquisitiveness is best developed when we make them face a problem to solve. This attempt of the teacher to place them in a cross-road situation will make them devise experiments, acquire first hand informations, organise them and think of arriving at a solution. Hence the effective technique should naturally create a problem to start with. Science teachers in India will have to pay proper attention to this aspect of the technique. This is invariably to be done as an unavoidable part of the work at the end of the introductory step. Sometimes the problem is felt by the pupils themselves and at other times the teacher leads them to realise the problem.

iii. Motivation, the driving force for the Pupils' intellectual activities

Though there is a problem before the pupils it can never be solved unless the pupils' interests are activated. These interests may be of a native type with the urge for knowing new things. They may be of a

secondary type, ~~of interest~~ with the urge to satisfy a strongly felt purpose. In the secondary school science teaching it is the latter type of interest that generally participates. Naturally, it is usual to correlate the purpose with a social interest. Hence the teacher uses an introduction of human or social interest. This strong purpose serves as the motive force, and the potential energy of interests becomes the dynamic attention to solve the problem. The initial motivation is kept up till the problem is solved or the lesson is learnt.

iv. Demonstration of Experiments.

Experiments in science class at this level, are generally intended to develop the matter and not for verifying laws or principles already learnt. Hence, the teacher to start with, should clarify the subject of the experiment and direct the pupils to observe certain aspects of the results. It is advisable to provide each student a set of apparatus to try. But it will be impossible to have as many sets of apparatus as there are pupils. Further, some of the experiments are complicated in nature and the pupils may not be able to conduct. One may feel under those circumstances, the need for calling pupils to the demonstration table to observe teacher's demonstration of the experiment. As the strength of the class will be as high as 50 or 60 this will lead to indiscipline and hence not advisable to adopt.

It is usual with the Indian science teacher to call the attention of the pupils to the various apparatus and how they are to be arranged

while conducting the experiment. He will even indicate the various precautions to be taken while conducting the experiments. In fact, those mechanical skills connected with experiments can be best developed by providing them with the apparatus for conducting the experiments. But it is impossible at present to make them conduct experiments in the lecture-demonstration class due to reasons aforesaid.

V. Pupils' Co-operation

Since every aspect of the educative process involves both pupils' participation and teacher's guidance, it is but imperative that science teaching should seek the co-operation of the pupils in the development of the topic. Though we notice this feature in the work of every science teacher, the extent to which the pupils' co-operation is sought varies. This co-operation may take different forms. The pupils may be asked to assist in conducting the experiment, in recording the facts and figures; or certain answers from one pupil may be elicited to the benefit of the rest. The teacher by this technique may also keep up the motivation of the pupils.

vi. The three steps in the development

In almost all the inductive lessons experiments form the major and preliminary aspect of the activity. The teacher elicits at the next stage, the facts and figures observed by the pupils. At the third stage, through well directed questions, the teacher leads them on to solve the problem or to conclude. The skill of the teacher can be estimated by the way in which he guides them to realise the principle

that is hiding in the web of facts and figures. This stage of the lesson is intended to develop in them, the habit of scientific thinking, clear judgment and reasoning. Indian science teachers strongly believe in the statement that the pupils should always have an open mindedness, so essential for scientific pursuits. While leading the pupils from facts to generalisation they are warned not to jump into conclusion but to be cautious.

If it is a deductive lesson the teacher draws the attention of the pupils to the problems of life. This will be the first stage. In the next stage, he guides them to find out the principle (already learnt) that can help them to solve the problem. In the third step the pupils are guided to apply that principle to solve the problem before them.

Whether it is an inductive or a deductive type of lesson the pupils have to develop the habit of thinking, acting and behaving in a scientific way. Above all, the pupils should get into the scientific mood which should ultimately develop in them, the scientific method of living.

vii. Diagrams and Sketches

Topics of science generally deal with matter and energy. For developing those topics experiments are usually conducted. It will be necessary in all science classes, to help the pupils to prepare sketches of those experiments. They have also to take down figures and diagrams which the teacher makes use of as aids to teach. Those illustrations will not only help the pupils to understand better in the class, but also to revise at home.

It is noticed in many schools, that the teacher writes the figure or diagram after the experiment is conducted or the topic is taught.

Some teachers may even write the figure on the board before the pupils come to the class. Both are unscientific. The figures or diagrams are intended to serve as teaching aids. What pupils comprehend through auditory impressions must be further strengthened through visual impressions. If these two things are simultaneously used learning will be more effective. Keeping the above psychological principle in view, it is to be concluded that the diagrams and figures should be developed on the board as the topic is developed or the experiment is progressing.

Certain topics of science can be better illustrated through photos or charts. But it should be remembered that they do not serve as models for the pupils to take down. The pupils can take down only line diagrams. So, even when teachers use prepared charts or other complicated printed illustrations it will be advisable to give a black-board diagram. Many teachers may get satisfied with the display of such charts.

Colours are used for black-board illustration. No doubt, they serve the purpose of making pupils to concentrate their attention on certain features or central points, in the figure. But there is a tendency with many, to use it for making the figures attractive. In reality use of colours will dissipate the interest of pupils. It should be restricted to the minimum essentials.

Some teachers in Indian Secondary Schools prepare their own charts and use them as aids to teach science. Of late, in certain states like Mysore, funds are set apart to help teachers to make their own teaching aids. This may encourage the teacher to prepare aids

which will help his pupils to understand the lesson better. If the teachers are provided suitable training in stuffing and preserving specimens, glass blowing etc., wood and metal work, they can prepare better aids for the purpose. The training institutions will have to think of providing such training facilities.

Viii. The assignment.

Though some schools do not encourage giving home work to pupils the majority of secondary schools in India set home work to pupils in science as in the case of other subjects. The teacher may ask the pupils to work out some problems based on a principle developed in the class or he may ask them to draw a diagram based on the subject taught. But, the pupils are not generally asked to do some fresh original independent work. This is the major defect in the nature of assignment. The assignment should be such as to keep them active in fresh investigation or in the application of principle learnt, to solve their own problems. After learning the parts of a certain flower the pupils will certainly show interest in studying the parts of a new flower. Similarly, innumerable examples can be given for other topics also. Hence, an activity assignment should be set as home work instead of purely writing work. This will encourage them to develop the spirit of inquiry and original investigation. Further, it will also help them to develop their power of expression in clay, colour or language.

Another important purpose of assignment is to develop the ability of applying principles to particular problems. The generalisations of science are not mere facts to be learnt but principles

to be applied. The assignment either in class or for home work, must ensure this aspect.

10. Technique Employed in the laboratory work:-

The success of the pupils' laboratory work largely depends upon the nature of topics, ~~to be~~ selected for practical treatment. Those experiments which are beyond the mechanical skill and ability of pupils should not be included for practical work, but should be reserved for the teachers' demonstration work. Further, there is need for maintaining a co-ordinated programme between the theoretical and practical work. A certain topic that is taken up for lecture demonstration, should be simultaneously drafted for practical work. If a particular topic taught in the theory class in the beginning of the year, were to be scheduled for the practical work at the end of the year, no useful purpose can be served. The laboratory work for the pupils in the Indian Secondary Schools is not satisfactory at present. There is need for bestowing better care in the selection of topics for practical treatment. Further, a closer co-ordination is to be maintained between theory and practical.

The class is generally divided into two batches. Sometimes the number in the batch will be so high that four to five pupils are to be grouped together to work with one set of apparatus. This naturally, means that an abler student dominates in the project while weaker pupils will remain simply observing. This may also contribute for certain unhealthy outcomes. The weaker pupils may try to copy down results of experiments though they have not actually done.

1. Teacher's guidance

LABORATORY	
CLASS ()	
Date 5-15-70	
Date 5-15-70	

The teacher generally prepares a cyclostyled instruction sheet. This will be put up on the board in the laboratory or copies of the same will be handed over to all pupils. It contains the name of the experiments, the problem to be solved and instructions, indicating the line of procedure. Many a time, the instructions given in the sheet will be quite inadequate. The teacher may write down the whole thing on the black-board.

In the beginning of the class, the teacher may ask all the pupils of the batch to come to his demonstration table and may demonstrate the experiment. Then they will go to their work benches to start the experiment.

Generally, the pupils follow the instructions given and conduct the experiment. They record all that they do including description of the experiment, a diagram of the apparatus used, facts and figures collected, observations made and the line on which they proceeded to conclude. The teacher keeps himself busy moving from bench to bench observing their work. He also sets them right if they have gone wrong in arranging the apparatus.

In many states practical work is arranged only for Physics and Chemistry. This makes the pupils think that science includes Physics and Chemistry only. In a few states practical work is arranged for Biology also.

ii. Valuation of Practical Records.

The Practical records of pupils must tell the true story of

what they did in the laboratory. It must indicate the apparatus they used, how they conducted the experiment, what they observed, the facts they recorded and how they arrived at the conclusion. It must even indicate the mistakes of pupils. The teacher generally insists that they must record every thing there alone. But usually this is not strictly followed. The pupils however, write something in the rough~~ly~~ note-book and get the signature of the teacher for that, so that they may go home and write down neatly in the record book. This practice leads to so many bad habits. They may copy down from another book or from a printed book and may even cook up figures.

The teacher goes through their records and returns them to the pupils by the next practical class. In some states marks obtained for practical work will be counted for moderation purpose; in other states they will not be considered.

11. Need for unifying theory and practical work:

The differentiation of the science programme into theory and practical is one of the reasons for its ineffectiveness. The short periods of 40 or 45 minutes set apart for theory will not be enough for the pupils to conduct experiments; so, they will be without adequate activity in the theory class. The laboratory work is not satisfactorily done due to reasons stated in the earlier pages. Hence it is felt that the separate laboratory work and lecture system are not advisable in the case of general science programme. In this connection it may be mentioned that out of the total periods set apart for science there must be at least, ~~three~~ double periods of 80 minutes each, ~~double~~ in the case of optional Science, and one double period in the case of General Science.

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should be taken into consideration in perfecting any science teaching method. In addition to the experiments to develop the topic, a number of aids can be used to make teaching effective and learning easier. Among those aids working models, ordinary models, preserved and stuffed specimens, charts, diagrams, films, filmstrips and optical aids are important. Efforts are being made to get as many aids as possible in every school for the science departments. Schools in general, possess microscopes, mounted lens, enlarging or magnifying lens, epidiascopes, etc. Of late, the training colleges are demonstrating the use of microprojectors for teaching microtopics in Biological science.

In addition to the need for having ready made teaching aids it will be necessary for every teacher to prepare his own teaching aids, useful for his particular technique of teaching. Teachers' colleges give training to the science teachers in the work of constructing teaching aids. Some Universities have made it a rule that each pupil-teacher should submit some sort of teaching aid, specially designed by him, as partial requirement, for his course. This has given impetus for the science teachers to devise their own teaching aids. A list of such aids which the science teachers generally prepare is given below:

1. Microsection slides,
2. Diagram slides,
3. Charts and Photographs,
4. Diagrammatic representations,
5. Stuffed and preserved specimens,
6. Collection of plants and plant parts,
7. Collection of shells, bones, etc.,
8. Birds' nests and insect nests,
9. Working models,

10. Film strips,
11. Enlarged models of animal and plant parts,
etc.

Indeed the teachers require additional training for this purpose. Time and availability of materials and other facilities are also essential for this work.

13. Other Methods for science teaching:

No doubt, the Teachers' Colleges deal with a number of other techniques in addition to the lecture-demonstration and laboratory methods. The Heuristic method, the project method, the topical approach, the historical method, the assignment-discussion plan, the concentric method and the type species approach are important among them. No one can say that one is better than the other. Each one is suited for teaching certain topic of science for certain age group. To a great extent, the selection of method depends upon primarily, the aim of teaching and secondarily, upon the pupils' ability and interests. Every method has its own special features, and some good features too. Science teachers in India generally find it convenient to use the lecture-demonstration method. But, they have to make use of the best principles of all the other methods. A list is given below to show the particular feature that is generally of interest in each of the above techniques:

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|---------------------------|---|
| 1. The Heuristic method: | To arouse curiosity for intellectual adventure. |
| 2. The Project method: | To study things in their natural setting. |
| 3. The topical approach: | To give human touch to lessons. |
| 4. The historical method: | To mention the life of scientists and to develop cultural aspect. |

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|------------------------------------|--|
| 5. The assignment-discussion Plan: | To organise debates on topics of science. |
| 6. The Concentric method: | For curriculum making. |
| 7. The Type species Approach: | For guiding the pupils to know more about the related forms. |

It is to be realised in this connection, that the general technique to be followed by the teacher is neither this nor that. Rather it shall be the composite technique, evolved by selecting the best features from many contemporary techniques.

The Type Species Approach:

This technique which is purely an American contribution, is largely being followed in India for teaching Optional Biology. The abler students at the age of 14+, have to select their Optional Subjects in the Indian Secondary Schools. The curriculum in Optional Biology is such as to introduce the pupils to the various classes of animals and plants through a single representative species. This is necessitated because of the impossibility of teaching thousands of available species in each phylum. By a study of the particular typical example of the class, the students are enabled to have an insight into the general features of the entire class of animals or plants. For this purpose, the Type Species Approach which was first elaborated by Preston has become quite popular among Biology Teachers in India.⁶

Film-show as the Integral part of the teaching technique:

Though films are being used in Indian Secondary schools from a quarter of a century, it is really a recent effort to make use of them as an effective visual aid. Of late the American, the English and the Indian film corporations are producing good educational films.

some of them are well designed and useful to use in the actual class-room setting. Among them 'The Digestion of Food in Man', 'The Circulation of Blood', 'Reproduction in Man', 'Excretion in Man', 'Dispersal of Fruits and Seeds', are some of the important educational films. In recent years a number of other films on different topics of the various branches of sciences of science are produced. At first, they were merely used to supplement what was being taught in the class. It used to look as if it is a mere entertainment programme. The teachers' colleges have devised a new and effective technique to make use of those educational films. The film, after a suitable introduction will be shown to the class. Generally, there is a good and effective commentary. After the film-show the teacher with the aid of a set of directed questions, will elicit the various features of the topic. In fact, the film is used as the material of instruction. It serves as the major source material, on the basis of which the entire lesson is to be developed. The special feature of this method is that the demonstration of the film is used as the integral part of the class-room technique, and not as a mere visual aid.

In fact, the pupils cannot be active in this method in the sense that they cannot conduct any experiment. But the interest of the boys and girls is maintained throughout. The teachers' introduction provides adequate motive force. The directed questions in the remaining part of the lesson, will also prompt them to think and to be active. In fact, it may not be a good technique for teaching some topics in Chemistry and Physics where experiments and mathematical reasoning play a great part. It is really a boon in teaching certain

topics of biology, particularly human physiology where life activities associated with physical and chemical changes, are taking place. No teaching aid or experiment can better demonstrate to the pupils, how the various physiological activities take place inside the human body.

The above technique of using films as the material of instruction was first begun in the Teachers' Colleges and is becoming popular in some of the metropolitan schools. The technique however, has yet to become popular in the rural schools. It may take a long time to enter into the rural schools, because of the scarcity of projectors and difficulty of getting the required films at the required time.⁷

In some cities of India, a Central Film Library is being organised so that the schools can draw the necessary films as and when they require.

14. Exploration of the Educational Possibilities of Community Resources:

It is essential to realise that every subject, to be taught in the school, has a domestic and social background. Naturally, a good lot of material found there, will be of educational interest. The school societies, the family and the society with its manifold organisations will serve useful resources for the children to explore. In fact history, geography, literature and other older school subjects are always associated with the domestic and social life. Because, they being the earlier achievements of mankind, naturally, dominated in the domestic, social and political life of the people. Science

is the youngest in the family of human achievements; naturally, it has recently begun to enter into the texture of the domestic and social life of the people. Though it is the youngest, it is the singular achievement of man that has the largest application in his life. I mean, science plays the most dominant part in every field of human activity. There is not a single field in which its influence has not been felt. As such the family, the society and all the institutions provide ample opportunity for the study of science. In recent years, it is felt that all that a student should know cannot be taught within the four walls of the class room. This aspect is being realised by some of the science teachers. Schools are giving equal prominence to the study of science outside the class-room. Some schools may call it extra-curricular activities, others may call it co-curricular activities. Of late the Wardha Scheme of Education which is the contribution of India to the progress of modern educational theory and practice, has stressed the importance of making use of all social facilities to the educational advantages; such activities are called in the Wardha scheme of education as "the Cor-related Activities". This has received the approbation of educationists and teachers at all levels. Hence secondary schools feel it important to explore the community resources to the educational advantages.

As in other countries, science is influencing the domestic, industrial and social life of the people in India. Even in the remotest corners of the country the modern machineries are in operation. Roads, communications, transport, agriculture, industries, commerce, organised institutions are all full of scientific atmosphere. The

pupils can learn a good lot of science in a practical setting, through those community resources. The science teachers in the secondary schools are fully aware of the educational potentialities of these resources. They can prepare an annual programme of work for the exploration of the community resources. A list of such items are given below to serve as illustrations:

1. Studying the Town Water Supply
2. Studying the work of the Health Service Unit
3. Studying the Hydroelectric Project
4. Visit to Sanitary Departments
5. Visit to the Hospital
6. Visit to Factories
7. Visit to Exhibitions and Industrial Fairs.
8. Visit to the Zoo.
9. Visit to Botanical and Horticultural Shows.
10. Visit to Forest Plantations.
11. Visit to the Telegraphic Exchange.
12. Field Trips.
13. Excursions.

In fact, the above community resources are to be considered as part of materials of instruction. Unless they are used, instruction is incomplete.

The problem of exploring the community resources is intimately associated with the availability of time and finance. Schools, take the pupils to the places of visits on Saturdays and Sundays. This has made the pupils think that it is not part of the school work. But it is humanly impossible to provide a place for visits in the school time-table. However, the science teacher must have freedom to take the class out of the school, if he finds it necessary. This work will be largely facilitated if double periods are introduced for science teaching.

Another difficulty in the way, is financial in nature. Some schools collect money from the children whenever they think of going

out. Many a time the pupils feel it difficult to pay. Such pupils who cannot pay, will not be allowed to participate. So, a large number of pupils lose the benefit of this programme. It further makes them think that it is not educational but prely a luxury.

To make the above programme effective two suggestions may be mentioned. 1. The school time-table must be framed such as to include the study of community resources. The science teachers must have additional facility of freedom to take the class out if and when necessary. 2. The state must consider the expenditure incurred on this behalf as part of educational finance. If these two suggestions are implemented our science teaching can be enriched to a great extent; pupils can realise and appreciate the role, science is playing in the human society. Above all, they connect what they learn in the school with the society, thus bridging the gap that exists between education and life.

It should be mentioned in this connection that the teachers generally do not pay proper attention to the follow-up work. After visiting the community resource centre, the pupils must be asked to report. This will encourage them to develop their ability in expressional art. It is also essential to create proper motivation for the work by a previous talk to the pupils before going to the places; The teacher should try to guide them properly during visits so that they may get the maximum benefit out of it.

15. Preparation of Class Notes by Pupils:

The Training Colleges insist upon the division of the lesson into suitable thought units. Further, they also insist upon giving

a black-board summary at the end of each thought unit. This will no doubt, facilitate the children to take down the essential points of the portion, covered. Further, to help the pupils to take down the technical terms correctly, they will also be advised to write them on the board after their meaning is made clear. In actual practice, it is noticed that many teachers deviate a good lot from the above technique. Many teachers simply try to dictate elaborate notes. This results in the pupils neglect to learn the art of notes-taking; they simply learn the teachers' notes by heart. This fact is clearly indicated in their answer papers in which similar answers are reproduced. It is therefore essential to pay as much attention to this aspect as to the other aspects of technique. The black-board summary must be developed of course, with the co-operation of the pupils. But the teacher should see that only the essential aspect of each unit is developed on the black-board. The pupils should be asked to study the details in the text-books or other source materials. The teacher as in other subjects, should guide them properly in the art of notes-taking. This will enable them to prepare lecture notes in the college classes. The teacher may call for pupils' notes now and then, and go through them.

16. The School Science Club:

Every subject taught in the Secondary School has generally a platform or a club of its own. Similarly, the department of science should also organise a Science Club. Its activities should be so organised as to provide opportunities to the children to develop their potential interests, skills and abilities in science, in a social back-ground.

The following are some of the activities that can be organised:-

1. To start minor clubs to encourage hobbies of scientific nature among the pupils.
2. To arrange for the reading of papers, reports and discussions relating to their experience in science.
3. To invite scientists to speak on topics of scientific interest.
4. To encourage pupils to collect matters of scientific interest from newspapers and journals.
5. To provide light science literature to the pupils to read.
6. To maintain a school garden.
7. To look after the school aquarium, Vivarium, etc.
8. To organise science exhibition.
9. To collect materials for the school museum.
10. To plan and arrange excursions to places of scientific interest.

At present, only a few schools in India are having science clubs. Even in those schools where there are clubs, they are not functioning on sound basis. It is essential to see that clubs function effectively to enrich and broaden the scope of the school science programme. A more effective state and central educational leadership in this direction is being sponsored in recent days, through financial grants and technical assistance.⁸

17. Tests and Examinations in Science:

Just like other aspects of education in India, examination is also strongly centralised. Each state is having its board for the purpose. The external examinations will be held at the end of the secondary school course. There will be a single paper in science and questions are set separately in three parts, i.e., Physics,

Chemistry and Biology both in the Optional and General Science Schemes. Many of the questions will be of the traditional essay type. In recent years, as a result of the initiation by the Teachers' Colleges, many states are including new type tests also. It is possible to improve the present science question paper by increasing the proportion of new type tests. Of course the present scheme of examination in science as in other subjects, tries to measure only their ability to remember facts. Attempts are being made to introduce tests that can measure other objectives of science teaching also.

From the teacher's point of view the class tests which are conducted once or twice in every term, are more important. The teacher can thereby, understand the effectiveness of his method so that he can effect any change in his method if necessary. But no standardised new type tests are available in all states. Few tests that are standardised in India are in the regional languages. There is need for standardising tests in the regional languages of the different states. The method of valuation of the pupils' answers should also improve. The teacher should try to mark the mistakes and return the test papers early. He may maintain a case record for every student wherein he can record his particular weakness and watch his progress.

18. Diagnostic Testing and Remedial Practice in Science Programme:

Science is comparatively a new subject to the life of the Indians. It is noticed that the achievements of a large number of pupils will be particularly poor in this subject. A large number of pupils fall in the external examination, because of their comparatively poorer achievement in science. Hence, a new problem arises with regard to

those pupils, backward in science. In fact, they are pupils whose achievement can be improved by special treatment and individual attention. This statement is proved by the fact that a large number of such pupils go for private tuition or coaching classes. This situation has created a new problem in science teaching. Naturally, they have to devise some course of action, through which the backward pupils are specially treated.

The above problem does occur in other subjects also. Language, Mathematics, History and Geography have already evolved schemes to treat pupils who are backward in the respective subjects. The backward pupils are sorted out by administering diagnostic tests. Then, they are divided into remedial groups on the basis of their particular weaknesses. Each group is then, specially taught by suitable technique. This programme of diagnosis and remedial measures has proved quite successful in those fields.

It is noticed that a large number of pupils will be very poor in their achievement in science. Many a time, the teacher will have to revise the lessons for the benefit of such pupils. Yet, it is difficult to say whether they will be really benefitted by it. It is necessary to study their exact difficulties regularly, from the beginning and to administer suitable treatment. The need for constructing and standardising diagnostic tests in science is keenly felt. This naturally, leads on to inquire as to which are the specific abilities that go to form the total achievement in science. In fact, this is as new to the West as it is to India. However, it is considered that

the following are the specific abilities that go to form the achievement in science education:

1. Factual knowledge,
2. Ability to generalise,
3. Ability to apply principles to problems,
4. Scientific method.

Efforts are being made to construct suitable diagnostic tests and standardise them, on the above basis. After the tests are standardised it may be possible to sort out the weak and administer remedial treatment. Till then, the teachers and the schools cannot sit quiet. The educational mortality in science is so large that some sort of rough measures should be devised without delay.

Attempts are being made in India by the post-graduate students and the members of the staff of the Teachers' Colleges to standardise diagnostic tests for the purpose. Meanwhile, some science teachers can try to sort out the backward pupils and provide them special instruction. The experiment has proved quite a success in many places. It remains for the states to make use of this technique as effectively as possible, to prevent the alarming wastage in science instruction at the secondary school level.

19. The Background Knowledge

Science is growing^{very} at a much more rapid rate than any other subject in the history of mankind. Naturally the wealth of scientific material is also increasing. It becomes a problem to the curriculum experts as to what to include and what not to include, from the huge wealth of science, in the school curriculum. Even if all the

topics are somehow, included in the curriculum, it will become a huge load to the class-room teacher. Even if the teacher were to attempt to cover all of them, it will become an unhealthy load on the children. The progressive countries have already realised this aspect of science teaching. America, while tackling this problem, has resorted to teach only the essentials in the class and treat the rest as background knowledge. Many schools in America are trying to provide this background knowledge through the exploration of the scientific possibilities of the community resources. England of course, is trying to provide pupils with the background knowledge in science, through films, radio, television, etc. It is difficult to state which of the above two is a more effective solution. So far as India is concerned, it is advisable to make use of both these techniques. Some of the schools are getting films from the circulating film library. Seminars and workshops are being organised both at the state level and at the central level to train science teachers in the effective use of visual aids. Each state is now laying emphasis on the correlated activities in science teaching. The community resources may also be used to provide additional background knowledge in science, which cannot be provided in the class room.

This problem may look insignificant to-day. But a time will come shortly, when this problem assumes serious form and proportion, as the subject of science is rapidly increasing in the wealth of its contents.

20. The Newly Designed Multipurpose Schools:

The Government of India is setting ^apart a large sum of money,

every year, to aid the states to start new type of secondary schools which they have designated as Multipurpose Schools. These schools are the contributions of India to modern educational practice at the Secondary School level. As the name indicates, these schools will cater for the needs of varying interests, abilities and aptitudes of children. One may feel that India has designed these new schools on the lines of some secondary schools now in existence, in the three progressive countries of the world. They are:

1. The secondary technical schools of U.K.
2. The comprehensive schools of America
3. The labour centred complex schools of Russia.

Though the multipurpose schools of India do possess some of the special features of each of the above three types of secondary schools, they are purely of an Indian origin, designed to suit the needs of India.

Though it is not necessary to describe a Multipurpose School here, it may be useful to know the nature of science programme there. Pupils are admitted at the age of 13+ and it is a course of 4 years. In the second year, pupils are to be divided into two streams on the results of an examination consisting of intelligence tests cum achievement tests and aptitude test. Those who possess high I.Q. and aptitude for higher academic education, will be advised to go for cultural education. They can study either science and mathematics or humanities as special subjects. They form the cultural stream. The other stream is the vocational stream. This diversification is partly, intended to avoid rush in the University and partly, to provide education suited to pupils' tastes and abilities. To whatever stream the

pupil may belong, he, has to study general science.¹ But the pupils of the science and mathematics group of the cultural stream, will have to study science and mathematics as elective subjects; pupils of the vocational stream will have to study applied science in addition to the vocational subject. Three or four periods of 45 minutes each are allotted for general science, per week. This is found thoroughly inadequate. ~~Three~~ double periods of 80 or 90 minutes each and nine single periods are allotted for optional science. It is interesting to note that the applied science course varies from vocation to vocation. Only that amount of science relevant to that particular craft is included as the applied science. This can be compared with the so-called background science intended for students of the secondary technical schools and secondary modern schools of England.

21. The problem of the Abler Child:

The introduction of general science in India will naturally raise the problem of science education for the abler children. Those pupils whose I.Q. is above 130 may be considered as the abler children. No doubt, their percentage will be too small. Yet, some sort of provision should be made to provide them education suited to their ability. In the present set-up of the secondary schools they are permitted to take up additional optional science. In the new set-up also they will be permitted to study optional or elective science. But they have to study general science also which is designed for ~~the~~ all the children. Moreover, India is convinced that a background of general science at least till the 18th year, will help them to specialise in any branch of science, in later ages. The newly designed multipurpose school

which has provided for the diversification of pupils at the age of 14 into cultural and vocational streams, provides three types of science courses:-

1. General Science Course for all.
2. Optional Science Course as electives to the abler ones.
3. Background or applied science to the pupils of the Vocational stream.

There is provision both in the existing and in the new set-up of secondary schools, to provide science education suited to the interest and ability of pupils.

22. Inspection and Direction:

The Secondary Schools of India are under the control of the State Director of Education. The Deputy Director or the District Educational Officer will conduct the inspection of the school. Many a time, the inspecting officer may not have studied science in his University Course. Yet, he is eligible to sit in judgment over the work of the science teacher. There are two disadvantages of such a type of Inspection:-

1. The teacher's worth may be wrongly estimated;
2. The teacher may not get correct guidance to improve his work.

This problem has already engaged the attention of all the state departments of education. Efforts are being made to employ Subject Inspectors. Each Subject Inspector will go and inspect the teaching of his subject. The Educational Officer or Deputy Director may inspect the school work later, and may prepare inspection notes, basing his opinions on the individual reports of the subject inspectors. If this scheme is given effect to, the teacher will receive proper help from

a qualified person to improve his work.

The Science Teacher and His Problems:

Science teaching is developing into a distinct profession. Every where, science teachers have organised professional bodies to improve their social and professional status. The science teachers of India have also felt the need for organising themselves. In a recent conference of Science teachers and Method Masters held at Simla, it has been resolved that a national body of science teachers should be formed on the lines of the Science Masters Association of England. Attempts are being made to organise the same early. The Organisation naturally, will have to work not merely, to improve the social and professional status of science teachers, but also as an organised authority to consider problems of science education in Indian schools and colleges and suggest means and methods of improving Science Programme in all grades of instruction.

At present the science teachers in India are facing four major problems. They are considered below, in order of their urgency.

1. Need for adequate time to prepare or set up apparatus for class demonstration:

Generally the science teacher like other teachers in the secondary school, has a heavy load of work. He has to work for about five periods every day. Naturally he will have no time to test the apparatus before actually demonstrating the same, ⁱⁿ before the class. It is no wonder, if many a time, his experimental operations go unsuccessful. This makes him an object of ridicule in the class and pupils lose confidence in him. It is therefore, essential to arrange school time-table such as to leave enough time for the teacher's testing his

demonstration experiments. Hence, this problem is to be tackled with all the urgency both in the interest of the teacher and in the interest of effective science instruction in the school.

ii. Proper Laboratory equipment and management

Laboratories in many of the secondary schools, are without proper equipment. The grant for fresh purchase of materials, apparatus, specimens and chemicals, will be quite inadequate for the purpose. The teacher will be unable to provide suitable activity to children. This naturally, makes the science class a dull room of mere talks. The educational advantage of a well equipped laboratory should be realised. The teacher must be able to command all materials he wants, both for class-room demonstrations and for pupils' practical work.

iii. Need for a common national Platform

Though there are various organisations for other teachers in India there is no separate organisation for science teachers to express their difficulties and discuss their problems. The formation of a National Science Masters Association will provide a common Platform for science teachers to seek redress to their grievances and also to offer their expert advice in the matter of curriculum construction, class-room technique, schedule of work, etc., which will go a long way to improve science instruction in the country.

There is a further need for organising Science Masters' Associations at the state level also. This body will function to improve

science programme within the state in particular. It can derive professional inspiration from the national organisation of science masters.

iv. Need for facility for professional training

Science as a subject of study, is increasing every day, both in quality and in quantity. The present decade has witnessed not merely the growth and application of the accumulated wealth of scientific knowledge, but also the change of our conception regarding the ultimate nature of matter and other things. It is not wise to ask a teacher to teach his pupils without knowing these marvellous changes. Hence it is necessary to arrange refresher courses in basic sciences so that the science teachers can try to keep themselves abreast of the growing subject. Far-reaching changes are also taking place both in the educational theory and in its practice; this necessitates the need for organising short-time professional courses so that they may acquaint themselves with some of the newer techniques and teaching aids that have come into the field, after they were trained in the teachers' colleges.

The Training of teachers should be considered as the combined responsibility of the Centre and the States. Conferences, Seminars, Workshops and refresher courses should be held both at the state level and at the central level. This problem should receive the urgent consideration by all those concerned, to ensure the necessary background for an effective science programme in the schools.

An Insight into the Future:

India's past glory stands on her achievement in the field of

Art, Religion and Philosophy. But the nation has realised that it is essential to organise its social and industrial life on modern lines. For this purpose, periodical plans for industrial and social progress are prepared. Naturally, India wants technicians, overseers and skilled workers to man the old and new industrial concerns. It is realised that science instruction at the primary and the secondary school levels should provide a suitable foundation for this purpose. Science programme is also being reorganised at all grades of instruction to ensure the production of requisite man-power for our industries and to create a nation that lives up to and appreciates the culture and civilisation of the age of science.



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CHAPTER IV

The Increasing Demand for Science Education

India has always endeavoured to make use of science for the benefit of mankind. Though the need for developing our industries, agriculture, transport and communications on scientific lines, is stressed in the earlier pages, the country has already commenced to progress on those lines. There is a stable and democratic central government with its well developed administrative machinery, based on modern means and methods. The various parts of the vast country are linked up with one another by a net-work of transports and communications. Throughout the length and breadth of the country the water of the great rivers is fully used through well planned irrigation works and river valley projects. Its merchant vessels and air liners play over the globe, thus connecting with India, the rest of the mankind. In recent years, the nation has resorted to planned economy based on Industrial development. The natural resources are being surveyed and attempts are made to harness them to the nation's good. A number of hydroelectric projects have been developed all over the country. The power thus generated is used to run the industries on the one hand, and for irrigation on the other; villages, towns and cities are being illuminated with the same source. In all these nation-building activities, science is playing a positive role. This fact has been realised by the nation and it has established throughout the country innumerable institutions of various grades, where science is taught among other subjects. In recent years, emphasis is being laid on introducing science even into the primary or the basic schools. Further, the first atomic reactor is already in operation

and the nation has evolved a plan to harness the energy of the atom for ^{the} peaceful use of mankind, thus intending to supplement the power generated by other means. In addition, a system of National Laboratories has been organised for carrying on scientific investigations. Thus, Science is playing an increasingly important role in the individual and the social life of the nation.

The only Path of Progress:

The majority of people in India are agriculturists. The advent of industry is attracting more and more people to work in factories. Even those who depend upon farming for their living, have recognised that improved and scientific techniques in agriculture will be more profitable. Both the villagers and the town people are evincing keen interest in the nation's economic plans. They rejoice at the great stride the country is making in the industrial field. They are proud to see their power projects, their metallurgical works and various other factories and transports and communications. Though the people are essentially religious minded, they have realised that India like other progressive countries, has to build its national economy on an industrial basis. They do appreciate the potentialities of science which is at the basis of all industries. Their democratic responsibilities have compelled them to take greater and greater interests in the country's plan to step up industries, since that is the only way of creating a welfare state. Even those people living in the remotest villages of the country, have felt the positive effects of science in improving their living conditions. In the daily life of every individual, whether urban or rural, innumerable applications of science can be noticed. It is also

true that science is playing a special role in influencing the unsophisticated villagers to discard many of the evil traditions. The individual is gradually endorsing the spirit of realism and rational outlook. Thus there is a process of revolution going on in the life of the individual, both in his emotional and in his spiritual outlook. Though science and technology are not so much developed as in the western countries, they are certainly developed to the extent of playing an increasing role in revolutionising the life of the individual and the community.

Science in General Education:

The people of India have realised the potential contribution of science to the progress of mankind. They have also realised that many of the evils wrought by superstition, will vanish as science advances into the life of the individual and the community. Naturally, there is a growing desire on the part of the thinking public, that every scheme of general education should provide a place for science. Science is considered to-day, as important, if not more important, as any other subject of study in the school.

In the primary schools of England and Wales, Nature Study is being taught as a separate subject. The teachers have felt the inadequacy of the scope of the subject to a modern child. They do feel that they have to teach some aspects of science, in addition. Though the educators and teachers do not like to change the name of the subject, they have realised that some aspects of the achievements of man can be included as topics of study. Some of the teachers do teach some such topics of science, interesting to the children. Such a course will take the form of general science. Nature Study does exist as a

subject of study in the Primary schools of India. As early as 1937 the leaders of the country detected its inadequacy, and recommended the introduction of General Science in its place. The Basic Education Committee gave a definite place for general science in the courses of studies for the basic schools. At present, most of the children discontinue their studies after primary education. Hence, it becomes all the more important to include science as a subject of study in the primary schools. Then only it will be possible to make primary education complete by itself.

Secondary education which extends up to 17th year of age has still greater significance to the political, economic and the industrial life of both the individual and the society. Since a good number of students who enter the secondary schools, will discontinue their studies at the end of the course, the secondary education should provide a complete general education to one and all. This naturally implies that a course of general science should be included as a compulsory subject of study in the secondary schools. Then only it will be possible for those who enter into life immediately, to participate in the various fields of activities as successful individuals and intelligent citizens.

In England and Wales all the institutions above the primary schools have now become secondary schools¹. Whether Grammar, Modern or Technical ^{the Secondary} Schools ~~are~~ are primarily institutions to provide general education. In India, a great variety of institutions that admit pupils after their primary education, are purely technical schools and are devoted for the instruction of one or the other vocational subject. Naturally, they do not consider that their primary purpose is to provide

a general education. Agricultural schools, commercial schools and horticultural schools are some of the institutions of that type. In England, Wales and Scotland, all such institutions have now, become secondary schools. Naturally they have included science as a subject of study. Hence it is essential to include all subjects in general, and science in particular, in the curriculum of such technical schools in India, as mentioned above.

Science as a subject of general education, even in the secondary schools, is only the basic minimum scientific equipment that is essential for every citizen. It does not mean that no more science need be taught in advanced courses, for general education. In England, Wales and Scotland, no doubt, science is studied in the Universities only by a few that too, as a subject of specialisation. No older Universities are teaching science for all, as a subject of general education. But it is interesting to note that this idea of providing a general education through science, is being experimented in one of the new Universities namely, the North Staffordshire University at Keele. In its four year course, the first year is devoted for foundational studies. Whether a student is going to specialise later, in arts or science, he has to study in the first year, both experimental and social sciences as well as the humanities. This, no doubt, is a new ideology in the philosophy of English University education. But the soundness of the new scheme has certainly attracted the attention of many progressive educationists. The growing wealth of science and its myriad applications to life, have made us realise that even the secondary school science instruction as a part of general education, is not adequate for future citizens. In whatever subject one may

specialise in the University, he does require a higher background knowledge of science, if at all he wants to serve the cause of an every-increasing industrial society. The message of this new experimentation in the field of English University education is that specialisation in the University should be undertaken on a firm and broad base of general education. Science certainly, forms an important subject of such a general education. Indian universities will have to consider this aspect of the English philosophy of University Education. They can so design their courses of studies as to provide a sound general education to all students whether they are taking up humanities, social studies or science subjects, for their specialisation.

Now, it is essential to say a few words about the place of science in adult education. The scope of adult education in India, no doubt, is quite different from that in U.K. or U.S.A. In the latter countries where education is compulsory, adult education takes the form of providing further education to those who could not continue their studies as regular students but entered into life directly. The Workers' Educational Association, The University extra-mural departments, the Evening Institutes and other social organisations are the important bodies that are responsible for this work in those countries. Invariably science and its applications do find an important place in the programmes of those bodies. In India, where education is yet to become compulsory, the percentage of illiteracy is so high that the main scope of adult education has been to wipe out illiteracy and spread literacy among the millions that had no opportunity to study in schools, in their younger days. In many of the states adult education associations are started and a net-work of literacy centres are opened. Sooner or later the states will have to provide general or professional

education to those who could not continue their studies further in schools. The educated adults also require some provisions to develop their interests. Hence the scope of adult education has to increase from literacy work to regular provision for further education. Certainly, science should find a prominent place in their courses of instruction at all levels.

Therefore, in addition to the existing provision of science as a subject of general education at various grades of instruction, new provision is to be made in certain fields like primary schools, adult education and University education. This is justified by the fact that our industries are rapidly growing and that the life is fast becoming more and more complex and technical.

What purpose shall our Science Education Serve ?

One may be tempted to prepare a long list of aims of science teaching. But an English Science teacher generally contents himself by laying emphasis on the following four objectives:

1. Practical aim:- To provide ability to pupils to understand and live harmoniously with their physical, social and material environments.
2. Vocational aim:- To provide the ability to learn a trade or to take up a job and discharge the same with intelligence and insight to earn his livelihood.
3. Disciplinary aim:- To Provide a systematic knowledge of science to the pupils and to train them in the correct habit of thinking, doing and behaving which should form the necessary equipment of the personality of the citizens of the scientific age.
4. Cultural aim:- To provide that amount of scientific insight and information which shall form the mental make-up of every individual who would like to appreciate and understand the human endeavour in shaping the texture of the industrial ~~and~~ civilisation, so characteristic of the scientific age.

The above paragraph refers evidently, to the aims of teaching science at the secondary schools. It is essential to assess the objectives of teaching science in the primary school. The objectives of teaching Nature Study were mainly:

1. to train the pupils in the work of observation and other abilities that serve to lay the foundation for the systematic study of science.
2. to train the children in the power of expression.
3. to create an interest in nature.

These objectives, certainly, are essential and provide a basis for studying science in the secondary schools. Those abilities like the habit of observing, interest in nature and power of expression will go a long way in their learning science. But, one more item is to be added in connection with the objectives of teaching general science in the primary school. After all, the scope of Nature Study when extended into the field of human achievement, ^{admits} an appreciation of the human achievement. ~~or even~~ ^{This} can be comfortably added as the fourth objective of teaching science in the primary school. But American educators do not distinguish between the aims of teaching science at the primary schools from ~~that~~ of the secondary schools. They consider that the aim of teaching science is the same at all levels and feel that each stage of the child, will contribute its own part towards realising the total objectives set before. This aspect of the objectives of science teaching will be separately dealt with at a later stage in this volume.

Of the aims of teaching science at the secondary school, the above four objectives are the important ones. But the emphasis on each of these objectives varies from one type of school to another.

The disciplinary aim with its stress on systematic study of science, scholarship and rigour of laboratory method, is the special objective of teaching science in a Grammar School. In the Modern school the emphasis is on the practical aim. In the Technical School the emphasis shifts on to the vocational bias. No doubt, the cultural aim which involves both the ability on the part of the pupils, to understand and appreciate the human endeavour underlying the new civilisation and the training in the way of living in a scientific age, are certainly, cherished as important in all types of secondary schools. Hence, it becomes clear that the routine list of objectives cannot be followed as they are. Rather, their extent, scope and emphasis vary according to the nature of the pupils - their ability, aptitude interest and the general aim of education. Since the aim of science teaching greatly influences the teaching technique and the course contents, it is essential to consider to what extent, each of those objectives should influence the composite aim of teaching science in a secondary school.

The disciplinary aim of science teaching is in conformity with the demands of the University entrance examination. But how many of the students of the Grammar Schools in U.K. go to University for higher studies ? The percentage ranges from 6 to 7. Only a few of them take science as their subject of specialisation. Hence the emphasis on disciplinary aim in general, with respect to all students in the Grammar School, cannot be proper. From the modern and technical secondary schools, the students going to the Universities are very few and as such, the disciplinary aim cannot be so much emphasised.

Whether a student goes to the University or not, science education must help him in the practical aspects of his life. Hence this aspect of the objectives of science teaching is important for all students. So, the practical aim needs emphasis in all types of secondary schools. These words also hold good with the cultural values of science teaching. Whether they are students in a grammar school, modern school or technical school, they have to live in a society based on science and its applications. Naturally they have to equip themselves with the scientific culture. Whether he is destined to become a technologist, a politician, a tradesman or a farmer, he should know the dominant culture of the age. Hence, cultural aim of science teaching should be stressed in all types of secondary schools.

Some educationists may consider that emphasis on vocational bias should be the important objective of science teaching. This statement may seem proper with regard to the students of the technical secondary schools. A knowledge of the principles of science related to their vocational subjects, may help them to do their job better. But that is purely with regard to that amount of science which is directly related to their vocational subjects. It can be better called applied science, like mechanics. But general science is quite different from it and it should be remembered that it is part of the school curriculum intended for general education. A course of general science includes topics of many branches of science. Naturally to give vocational bias to such a science course, means stressing on the application of topics to innumerable industries. We do not know one's future course of life. Much less do we know what sort of vocation

in life he is to take up. Under these uncertain circumstances it seems meaningless to go on drawing the implications of each of the science topics to the related industries. So, vocational aim shall not loom large in teaching general science even in the technical secondary schools. Much less so with regard to other secondary schools. At best, the implications of this objective is only to draw the attention of the pupils to the practical application of the knowledge or skill they learn, to every day problems of life.

So, the objectives of teaching general science to any student of every type of secondary school, are mainly two-practical and cultural. Then only the inclusion of science as a subject of general education in the secondary school curriculum, can be justified.

In upholding the importance of practical and cultural aims of science teaching we are not underrating the importance of the disciplinary and the vocational objectives. They are also important since they are directly related to the progress of scientific investigation and the development of technology. But only a few members of a huge population may be destined to become research workers and technologists. Our secondary schools should foster and strengthen their talents. But there are separate courses of science for such pupils. In a Grammar School there is scope for taking up one or the other branches of science as Special Subject. The emphasis in teaching such a science course should be on the disciplinary value. This is also true with regard to the technical schools where the pupils will have to study the theoretical aspect of this vocational subject. It may be a course of applied science like mechanics, home-science, machine drawing, etc. The emphasis in

those courses should be on vocational objectives. Even those students are common individuals who have to live in a society, pervaded by the implications of science. Hence even though they have to study special sciences or applied sciences, they too have to study general science.

It is not our object to consider here even in the barest outline the objectives of teaching science in the Universities. But our work will be incomplete if we do not link up the objectives of science teaching in secondary schools, with those of teaching science at the University level. No doubt, in almost all the Universities, science is studied as a subject of specialisation. Even in the lowest grades of the University the objectives of science teaching is to provide the pupils, education in one or the other branches of science, ensuring particular discipline and deeper scholarship in that narrow field. In the later years of the University Course, it is to encourage independent study in a still narrower field of the subject, leading on to academic research work. This state of affair presupposes that science becomes a subject of vested interest in the Universities and that a general course of science for general education is unnecessary at that stage. In recent years, there is a revolt against this ideology. It is upheld in some quarters that growing complication of the human society and the rapid growth of technology demand some sort of science education even at the university level for one and all. This ideology is supported by the fact that the complexities of life are ever-increasing and as such, every individual should know much more of science than he can possibly study in his school days. It is interesting to note, that this new ideology is being experimented at Keela in the newly

started North Staffordshire University. The first year of the four year degree course is devoted for the study of three groups of subjects by all the students of the University. The first year course includes (1) Humanities (2) Social sciences and (3) Experimental Sciences. Whether the student is going to specialise in arts or science, he has to study the various branches of science. Thus it is a science course designed to provide a general education. This is expected to serve two purposes. Firstly, it has to help the student to equip himself with richer scientific informations to understand and appreciate the ever-increasing impact of science on human civilisation. Secondly, it has to serve as a broad foundation to specialise in any subject, in later years.²

There are two types of science courses in Indian secondary schools. One of them is for the gifted and talented few. That is the optional science course. The other is the general science intended for all. In the new educational set up the secondary schools will retain these two types of courses. The proposed multipurpose schools will have a vocational stream. The pupils of this stream will have to study the general science in addition to some applied sciences related to the particular vocational subject, they have selected. Naturally the objectives of science teaching is to be considered in the light of these provisions of a varied type, intended to meet the needs of the varying ability, needs and interests of pupils.

In India unlike in U.K., a good ^{percentage} number of pupils of the secondary schools proceed to the Universities for higher studies. Nearly 45% of the pupils that pass out of the secondary schools, join B.A. or B.Sc.

courses in India, where as it is only 6 or 7% in U.K. and a little higher in U.S.A. This state of affair is partly due to the high premium we have set on University qualifications and partly due to lack of adequate provisions for technical and further education facilities. In the new educational set up attempt is however, made to prevent too many pupils proceeding to the University, particularly those that cannot benefit by an academic type of education. This diversification is done at the secondary school level. Those that are likely to be benefitted by the University Education will be streamed out into academic stream, and only they can enter into the University. Their number naturally will be a small percentage. Even among them, a good number of pupils may choose arts subjects to specialise. So, those students have no more opportunities to study science. Hence, it is clear that to a great majority of pupils science for general education ends at the final years of the secondary schools. It should be borne in mind that like other subjects of the secondary schools, science also should be taught such as to provide a complete general education. Since the cultural and the practical objectives are important to one and all, the stress should be on the cultural and practical aims in teaching science for general education. With regard to the optional sciences, the stress should be on academic or disciplinary aim. But vocational objectives should dominate only in the teaching of applied sciences.

Nature Study in the Primary schools is giving place to general science. The objectives of teaching the subject, need also an expansion. In addition to train the children in the power of observation and expression and to create an interest in nature, the development of an insight into the achievement of man may be included.

The approach should be primarily to satisfy the curiosity of the pupils. This is a practical objective. Though we have advocated that general science should be taught at this level it must be made clear that we mean in its functional aspect and not in the formal aspect. The modern child in his everyday life will be coming in contact with hundreds of events exhibiting the witch-craft of modern machinery. Naturally, ~~they~~^{he} possess an interest to know the why and what of those wonders. Certainly, those interests of the child must be satisfied. But the way in which we do it should be suited to his ability. Even though we cannot make him understand how the aeroplane flies, we can make him understand that it is a machine made by man and used to carry men and material in the air, at a very fast rate. It is in this sense that we have advocated above, that the subject should be taught with an emphasis on its functional aspect.

At present, most of the Indian Universities provide courses of studies similar to those provided in the older Universities of U.K. This is quite natural since Indian Universities were organised in their model, to start with. Naturally, science like other subjects ~~are~~^{is a} subjects of specialisation from the very beginning. So, science is studied only by those who want to specialise in one or the other branches. There was practically no provision for teaching science to Non-Scientists ~~in~~ till very recently. From a couple of years, following the suggestions made by the University Education Commission (1948), the University Grants Commission and the Inter-University Board, a course of Science is being introduced for the non-science specialists in all the Universities of India. But there is a tendency to reorganise the courses of studies such as to have a broader start. In this connection

our experience of the ideology underlying the new University Centre at Keele, will certainly throw some light. The world of to-day is much more complicated than that of fifty years ago. Naturally science like other subjects of general education, need extension beyond the secondary school level. By this, we mean that in the early years of the University Education, a broad based aim of teaching science for general education, should be cherished, and specialisation should be postponed to the second year at least. Then it will be possible to build any specialisation in science on a broad general science education.

Similarly, the objectives of teaching science for those who could not continue after secondary schools or to those who had no opportunity to study in the secondary schools, should be primarily, to enable them to live as successful citizens in an ever-growing industrial society of a scientific age. Secondly, the aim should be such as to help them in the profession in which they are employed. Hence the stress should be not only on practical and cultural values but also on vocational objectives.

One of the serious social evils in India is the prevalence of a strong superstition in the minds of the majority of people. This fact is responsible for many of our fantastic beliefs and behaviours. For the progress of the society and for its adjustment to a new social order, based on the objective ways of living, this superstition should give place for realism and rational thinking. The spread of scientific outlook and the scientific method of tackling the problems of life will go a long way to wipe out superstition and its consequent evil effects. Hence, science teaching at all levels including that of adult education, should try to develop scientific outlook and scientific spirit. Though the method of science should develop as the end-

point of teaching science, it is possible while teaching, to indicate the scientific lines/^{on} which many problems of life can be solved. No other subject can claim to contribute to abolish superstition from the minds of the nation better than science. Hence, science teaching should aim at developing in the minds of the pupils and the people, the scientific outlook and scientific spirit as well as the objective ways of facing and solving the problems. ~~before us.~~

The importance of science as a subject of general education can here be considered in the light of the criteria for assessing the success or failure of the system of education of a community, particularly at the adolescent stage. Those criteria invented by Prof. Kandel as expressed in his recent publication entitled 'The New Era in Education', are stated below:-³

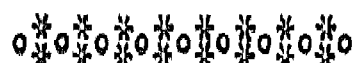
1. Are the schools developing young men and women who are informed and intelligent about the social, economic and political tasks for which all have some responsibility?
2. Are the schools producing young men and women who have an appreciation of the form of government under which they live and its meaning in terms of their responsibilities?
3. Are the schools inculcating ideals and standards of co-operative living in a democracy?
4. Are the schools insisting upon any recognisable standard of achievement?
5. Are the schools seeking to cultivate and disseminate intellectual and other interests that will stimulate further education after school days are over?
6. Are the schools turning out citizens equipped with higher moral standards and intelligence, trained to understand and meet the complexities of modern life?
7. Are the products of the school not only more intelligent but healthier, happier and better equipped than with traditional elementary education only?

The above questionnaire is based on the aims of secondary education. Every question is based on one or the other aspect of those objectives that contribute for the individual development on the one hand, and social efficiency on the other. A perusal of the realisation of those outcomes of education, indicates that science teaching invariably influences the child's life in every one of those aspects. This further lays emphasis on the paramount importance of an effective science programme in schools.

The modern advances in transport and communications have brought countries together so as to convert the whole world into a big family of nations. This naturally demands a better and a closer understanding among the nations. No nation can live aloof to-day. Hence science which has brought about this unavoidable necessity of co-operation and understanding among nations, can also help to translate this ideology to realism. As everyone knows, it is a subject that is never influenced by the narrow barriers of caste, community, creed or nationality. It is the asset of all nations and is developed by the common endeavour of all people. Naturally, it is full of potentialities to contribute for the growth of international understanding. But this aspect of the subject has not been fully realised by many of us. To that extent we are not making use of science as an instrument to spread peace and happiness among mankind. The science teachers certainly render a valuable service to mankind, and prevent its threatened destruction if they can endeavour to develop in the minds of the youngsters, the international responsibility, goodwill, co-operation and understanding, all of which, the world of to-day is so badly in need. The science teachers in India should cherish this as

one of the ultimate objectives of science teaching.

Herbert Spencer while advocating the inclusion of science in the school curriculum, prophesied in the middle of last century, that science which was then treated as the Cinderella in the family of knowledge, would soon emerge out as the most favourite princess of mankind. Within a century or so, the prophet's expectations have been over-realised. The wealth, the potentiality and the impact of science have so much developed that it has succeeded in revolutionising our outlook, our behaviour, our ways of living, our culture and civilisation. In the background of such a social order, science stands preeminently as a subject of general education to one and all, and of special education to many. It therefore, becomes the sacred responsibility of the leaders of the country to strive hard to extend the benefit of science education to one and all.



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CHAPTER V.

Progress of Science Education in England.

The English Universities remained mostly centres of imparting knowledge till the middle of the 19th century. This responsibility of handing over the cultural heritage of the nation, extended in the later part of the century, to the advancement of knowledge through the encouragement of research work. This provision for the extension of the existing boundaries of knowledge was meant not merely for students but also for the matured minds. Indeed, science teaching at the Universities to-day, is the outcome of the realisation of the fact that we cannot afford to wait for the occasional contributions by the unaided genius. As some knowledge of science was felt necessary for the professional purpose, the state and the society had to organise a system of science teaching. Now it is realised that a knowledge of science is necessary for every citizen living in this age of industrial civilization which has been inspired and guided by it. This realisation compelled the secondary and the elementary schools also, to introduce science in their curricula. But one cannot forget that the present established place of science in the school curricula was achieved not simply and automatically but as a result of the pressure of growing needs and insistent struggle. The history of this struggle is interesting both from the point of view of the growth and development of science and from the point of view of the influence on its methodology and organisation.

The beginning of Scientific spirit and the Dawn of Academic Science:

Roger Bacon in the middle of the 13th century, heralded the dawn

of the modern European Science. His "Compendium Studii Philosophie" emphasised the need for studying Natural Science. The interest he created, brought about a change from the formal to the experimental studies as a result of which the intellects were set to follow the course of realism in educational pursuits. The mediaeval universities which were founded just by that time, took to the study of the Greek classics to know that science. This classical revival was merely to study the science in the classics, and experiments in the 14th and 15th centuries were intended to verify Galen's statements. Through those dissections an interest was gradually developing in the study of Natural Science. In the year 1543, the birth of academic science was inaugurated by the publication of 'De Revolutionibus Orbium Celestium' of Copernicus and 'De Fabrica Corporis Humani' of Vasalius.¹ The publication of the latter original studies turned the attention of the intellects from the authorities of the classics to the realistic studies of science. The authority of Galen in the field of Natural Science, came to an end. Harvey set out to explain the mechanical movement of the heart and disapproved the sacred statements of the classics. This created^a/growing desire to investigate things rather, than to believe in others. Thus was laid the foundation for the experimental science.

Francis Bacon in the later part of the 16th century, announced a regular method for the study of science. He laid the foundation for the study of science and became the first philosopher of science and popularised the subject. His publication of the 'Advancement of Learning' appealed for the recognition of the supreme worth of science. Rene Descartes in the beginning of the 17th century, propounded the regular modern philosophy of science. His 'Discourses on Method' was

published in 1637. It indicates the main steps of the scientific methodology and the same is expressed in the following description of a scientific thinker:²

1. He never used to accept anything for true which he did not clearly know to be as such; he avoided precipitancy and prejudice.
2. He divided each of the difficulties into as many parts as possible.
3. He used to think by commencing with objects, simplest and easiest to know, and reach the more complex.
4. He used to make enumeration so complete and review so general, that nothing was omitted.

The first step in his method is doubt. The next step is the analysis of problem. The third step is the experimentation. The last step is generalisation. He recognised no outside authority but depended on reasoning. 'I think so; therefore I am so' was his method. This spirit of methodical study was further modified by the later discoverers like Newton and the spirit of experimental science became the character of the age. As a result, popular interest began to develop in the study of science. In 1662 the Royal Society of Science was founded for the encouragement and advancement of the study of science. By that time, science academies were formed in Italy, Germany and France. The study of science till then, was only for the philosophers who gave lectures now and then, both to the people and to the students.

From the beginning of the 13th century Grammar formed the core of the university curriculum. The influence of Aristotelianism was strong on the school studies. Some branches of science however, entered into University curriculum by 1636. But no place was given for Natural

science. The earlier subjects to enter into the university courses, were Mathematics, Astronomy and Physics as those branches of science were ahead in study^{and} development. The teaching naturally lagged behind the advancing knowledge. Till the 19th century public schools did not include science in their curriculum. In 1662 Botany was however, included by the Universities for medical students only. In 1836 Anatomy was introduced in London University as a subject of study. Later on, Philosophy also made its entry. By 1860, the Natural Science was also introduced.

Science into the Secondary Schools:

By the middle of the 19th century attempts were made to introduce science in the secondary schools of England. Some schools did not show interest while other schools readily introduced the same and even provided for practical work. The Public School Commission and the School Inquiry Commission were appointed to inquire into the position of science. These two Royal Commissions studied the curriculum of secondary schools and submitted their recommendations for the improvement of the place of Natural Science in the public schools. The Commission upheld the view that the study of science in the schools was important both from the individual and from the social points of view. The School Inquiry Commission in 1864, in their Report stated that Natural Science was practically excluded from the contents. They argued that science quickens and disciplines the faculty of observation which in very many persons lies dormant throughout life; that it develops the power of accurate and rapid generalisation and the mental habit of method and arrangement; that it trains them in the habit of chasing the sequences of cause and effect and familiarises them with the act of reasoning and corrects all sorts of indolence and lack of

alertness'. While upholding the importance of natural science they did not try to minimise the importance of classics! They recommended that one hour may be devoted to Natural Science and two main branches of the subject may be included in the syllabus. This was followed by some schools willingly, while other schools tried to have it merely for earning the grant. In reality, many schools did not show sufficient interest in introducing science. The schools were unwilling to accept science as a desirable companion of the other older branches of knowledge. But it was found to be the most useful subject by the outside society. The educational value of science began to develop into a subject of serious controversy. Carlyle accused science for 'destroying the mystery of the Universe'. Many classical scholars felt that it was making the 'rainbow cold'. But the head masters of public schools gradually had to face the reality and to find that science had come to stay. Provision had to be made to teach science in secondary schools. Laboratories had to be built. But it was difficult to get teachers for science. The well known scientists of that time, were merely unqualified philosophers. The Devonshire Commission in 1875, stated that science in addition to the imparting of knowledge, trains pupils in the habit of observation, reasoning and self-check.³ The committee felt that science was more important than any school subject, more easier than arithmetic and more interesting than any other subject.

As supported by Faraday, William Thomson, Ramsay and the teachers of Mechanic Institute of London and Evening Schools, the above Commission recommended that science may be taught from the age of twelfth year. They also stated that out of thirty five periods, six periods may be

devoted for the teaching of science in a week. The study of science was explored by the Commission with reference to its benevolent influence on the achievement in other school subjects including classics. So they recommended that:⁴

1. All Public and Endowed schools may devote six hours for the instruction of science in a week;
2. One sixth of the marks in the examination may be allotted to the Natural Science; and
3. The same proportion may be maintained in the school leaving examination also.

Object lessons in Primary Schools:

There was a demand for science teaching from the public even in the elementary schools. A Committee formed by the London School Board in 1871, recommended that a graded series of object lessons may be taught in the elementary schools.⁵ Herbert Spencer, Huxley and others tried to show the relation between science and life. London School Board soon issued a syllabus for object lesson. In 1881, about 7000 children in elementary schools took Animal Physiology; 411 took Botany and 51 took mechanics. This popularity of biological science was due to Huxley's books on Physiography and Physiology. Gladstone introduced an apparatus box for science experiment. This created in children, an interest in science hobbies. Teaching method consisted of oral lessons with the demonstration of simple things. In 1882, a Government Code was enacted that some phenomena from Nature, life and life-occupations may be listed for infant schools and that elementary science may be prescribed for senior schools. Thus some aspect of science entered into the school curriculum. But the subject

included things that were not science !

In 1889, the British Association Committee emphasised the need for having practical work and this resulted in the feeling that demonstration method was really good. H.E.Armstrong, a university professor of chemistry, introduced the practical method and the Heuristic study in secondary schools. This technique soon entered into elementary schools also. Very soon physical science was replaced by Nature Study as it could comfortably yield to heuristic treatment.

The education according to nature, postulated by Rosseau and worked out by Pestalozzi and Frobel, developed /object lesson as a technique of teaching. It did enjoy a brief popularity. But its contents were not purely science. Moreover, there was growing interest in science. Hence a new subject began to develop which was designated by Basedow a little earlier. Efforts were made to introduce it into elementary schools by the end of 19th century. From 1850 onwards, sporadic provision for practical work in Natural Science, particularly, in Zoology was made in some secondary schools. Though the Heuristic method prompted practical provision, the method itself went into disrepute! But other effective teaching methods were evolving. Science was fast becoming a subject of both profit and pleasure. It was about to be proclaimed 'highest alike in worth and beauty' as Spencer declared. But the Cinderella of the curriculum enjoyed only a brief triumph. The Board's Regulation of 1904 gave it a subordinate place again. It stated that any two branches ,

of science may be taught in the schools. As a result of this, only girls used to take Botany and that too to leave off after fifteen, in favour of domestic science. The above code also made the object lessons compulsory in the upper 3 standards. Full provision was however, made for those students who had to leave the school at 14, for teaching science in an effective method. This necessitated the inclusion of the methods of teaching object lessons and laboratory work in all training colleges.

The pressure of an external examination came in the way of the progress of the method of teaching science. In 1911 the Consultative Committee suggested certain changes in the scheme of examination and the pupils were allowed to pass in groups. This brought about further neglect of science since they could pass this group without studying science. The position had practically worsened when, in 1917, the Prime Ministers Committee was appointed to investigate, particularly the position of Natural Science. After careful enquiry, the committee expressed the following view:-⁶

1. General Science may be included till the sixteenth year.
2. For pupils under 16, plant and animal studies should be included in addition to Physics and Chemistry.
3. Every day aspects may be taken for consideration in those science courses.
4. All the pupils in the first school examination should pass in mathematics and science.
5. School results should be taken into account.
6. The Committee realised the need for practical work. It upheld the demonstration lesson as a very useful course particularly to deal with life problems as related to topics.
7. For pupils above 16 years upto 18th year, utility of science may be taught so that they may understand that the subject is one of human interest.

The British Association of Science started a systematic programme to guide the teachers in the progressive methodology of science teaching. In 1919, Gregory advocated after discussion, that the various examining bodies should revise their courses in science so that it may become complete and may anticipate college courses.

Gregory again in 1922, stated that science is not for embryonic doctors or engineers, chemists or biologists!⁷ He advocated that it must be for general education. The possibility of including such a general science course came to be seriously discussed by teachers and public throughout the country.

It is during this period of interest in science as a subject of general education, that the Science Masters Association of England brought out a report of discussion under 'General Science' to emphasise that 'the essence of general science lies not in the syllabus but in its interpretation'. But it is only a skillful teacher who can give the unity that is required for topics of various branches. This should be judged by the pupils' response as it is the essential factor in the educative process. Gradually, the country began to view that upto sixteen, academic and conventional teaching of science, is to be avoided. The Association recently issued a syllabus in 3 parts in conformity with the Prime Minister's Committee's Report. This syllabus in general science for secondary schools actually formed the basis for developing a science programme for general education in the secondary schools of England and Wales, and to some extent even in Scotland. The next chapter is devoted to a study of the recognition of the liberalising influences of such a course of science.



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CHAPTER VI.

Science as a Subject of Liberal Education

As a result of the great advance in science during the 19th century, it became more and more apparent that the legitimate claims of science to be included as an integral part of the curriculum for secondary schools, must be recognised. William Whewell, the celebrated master of Trinity College, Cambridge, urged in 1837, the claims of mathematics and science to be included as part of a liberal and academic education. The Prince Consort was keenly interested in the claims of science. Those claims were further stressed by the great Exhibition of 1851 which brought home to Englishmen their comparative backwardness in the application of science to industry. This was a powerful influence that made the public demand for the inclusion of science as an integral part of general education. Prof. T. H. Huxley delivered his famous address on the Educational value of the Natural History and Science; John Tyndall lectured on the importance of the study of physics as a branch of education; and Michael Faraday in a lecture on the education of the judgement, stressed the importance of cultivating the scientific spirit. Herbert Spencer in an article in the North British Review, took the view that a knowledge of life was more important than any other knowledge, whatsoever.¹ In 1859, in his book 'Education: Intellectual, moral and physical' concluded that knowledge of the various branches of Natural Science is of the highest value, and supported that a leading place should be given to Natural Science in formal education. Prof. T. H. Huxley was the most prominent

advocate of the teaching of Natural Science in the sixties and seventies. He urged that any proper scheme of education should respect the claims of science. He outlined a syllabus for secondary schools, giving a prominent place to Natural Science and thus exercised much influence on the public opinion regarding the teaching of science in schools.

The dissatisfaction of the public is clearly reflected in a book edited by Dean Farrar, Master of Harrow in 1867, regarding the neglect of Science. Prof. Sedgewick of Cambridge expressed the view that though science does not form part of the old culture, a man trained without it, will feel unable to comprehend the present phase of human progress, thoroughly.

In 1886, Canon J.M. Wilson, master of Rugby, stressed that the study of the two unlike branches of Natural Science, was a very necessary part of complete education. He considered education should develop in the pupils the habits of accurate observation, exact reasoning and the power to judge evidences which could be developed by good science teaching. Mathematics, in his view, did not serve the same purpose at least, to the same extent.

In 1875, the Royal Commission in their 6th Report on 'the Scientific Instruction and the Advancement of Science' as explained elsewhere, recommended that in all public and Endowed schools, not less than 6 periods per week, should be assigned to the teaching of Natural Science and in all the general public examinations, not less than one sixth of the marks to be allocated to that.² But what exactly was 'Natural Science' was not defined by them. However they stressed

the need for giving practical work in physics and chemistry. As a result of the recommendation of the Royal Commission on Scientific Instruction and the Advancement of Science, Natural Science especially, botany in girls' schools was introduced gradually, from 1875. Physics and Chemistry made their entry into the curriculum of the boys' schools.

'The part played by Natural Science in modern life is so important an element in the experience of boys and girls that its inclusion in the curriculum needs no special justification. But there is a general feeling that the common practice of concentrating on the systematic and formal study of a particular science, lays too early a stress on the 'Phase of Generalisation' and too little on the earlier phase of romance and utility and accordingly, is not the best approach to science for adolescent pupils. This feeling has already led to the provision of courses (and papers in the School Certificate Examination) in general science as alternatives to courses in particular sciences. These courses in general science aim at relating science to everyday life and experience. They avoid what is of a purely academic or formal nature and illustrate laws and general principles by special reference to practical applications drawn from the physical and biological world around. In this way general science makes a more direct contact with life and creates real interest. It appears probable that as experience is gained, these courses will move farther^{and} farther away from the particular courses of science both as regard to the materials and methods of treatment'.³

Regarding those pupils who leave at the age of 16, it is interesting and essential to consider the type of education they should receive.

Physics and Chemistry from the very beginning were too traditional. Science was introduced into the curriculum at a time when scientific inventions had focussed our attention on the physical and chemical environments and had created a demand for instruction mainly in Physics and Chemistry. Pupils who proceeded to the University continued those sciences only which they had studied at schools and when they came out as teachers naturally taught physics and chemistry which and as they had studied. But since that time, the horizon of science had widened very considerably. Biology began to attract more and more attention, and is now recognised as a subject of fundamental importance to man in relation to agriculture, horticulture, animal husbandry, medicine, nutrition, public health and other social services.

If science is to be a living subject, it must deal with pupils' own experience, and on the basis of that experience extend the horizon of his experience through his interest. But courses in sciences have not extended with the extending interests of pupils. The teaching of science has lost touch with life itself and, for this reason has often, failed either to give the knowledge required or to stimulate the pupils' interests⁴ in directions suited to the development of their personality. In the report of the Elementary Science Sub-Committee of the Science Masters' Association published in 1934, the subject ~~is~~ is defined as "A method of preserving the fundamental principles of science, based on the interpretation to the youth of the world in which he lives, involving not only the understanding of the fundamental principles but also of attitude and method of science generally." Science is regarded here, as a living whole, comprehending all the sectional sciences necessary to give the youth an intelligent understanding of his biological, chemical and physical environments. Its sub-committee in 1937,

enquiring into the teaching of general science, defined it as ' a course of scientific study and investigation which has its roots in the common experience of children and does not exclude any of the fundamental sciences. It seeks to elucidate the general principles observed in nature without emphasising the traditional division into specialised subjects, until such time as this is warranted by the developing unity of the separate parts of that field and by the intellectual progress of the pupils'.

The Spens Committee considered that there is a general body of knowledge, not confined to either of the physical or the biological fields of science, which ought to be known by an average citizen and by those who ultimately specialise in a particular part or one of those fields, and recommended in general, that each boy and girl should be taught that minimum knowledge of both the physical and the biological worlds. They also felt that nothing but the broadest outlines must be included in that subject and that such a general course should not be affected by the fact that some of those pupils may ultimately become specialists in any one of the narrow fields of science.

Science has been established in too short a time in the curriculum for an enduring tradition to have grown up. A generation ago, the method employed might have been criticised on the ground that there was too little practical work in the schools and that as a result the knowledge imparted fell short of reality. This situation may have to be attributed to the particular shortage of well-qualified teachers; but a more important factor is to be found in the insufficient laboratory accommodation and equipment at that time. But that condition does not now exist. The authorities realise the need for adequate place and

materials though they are not able to provide! The critics of existing science courses complain that the content is too small and the range covered is too narrow to be regarded as satisfactory for purpose of general education. Too often, the boy or girl is restricted to a single subject-course mainly in physics, chemistry or botany. In the recent times, a wider course of biology has replaced botany and some little chemistry also is being added to this widened course of science. But in many schools especially in boys' schools, there is still little beyond physical science and this is too often restricted to chemistry together with some sections of physics. The investigators of the School Certificate Examinations in England, criticised the scope of the examination syllabus in 1931. This has been accepted to be sound by the teaching profession.⁵ The Science Masters Association after careful consideration, have adopted the view that for the children upto the age of 16, science should be taught on a much broader basis and have produced a report to give further precision to the ideas connoted by the term 'General Science' (Teaching of General Science). The Spens Committee supporting the view of the Science Masters' Association, stated that the object of teaching science is to sponsor three types of appeals: The chief aim of teaching science as per their opinion should be the development of -

1. Individual Interests
and utility.

To provide some knowledge of Natural laws that operate in the universe together with an ability to apply them. This is an appeal to their wonder, interest and utility.

2. Social interest and
utility.

As a complement to the study, and history of science teaching should reveal the influence of scientific thought and achievement in the evolution of our present day civilisation

and even more important, it should indicate its possibilities for good and evil alike, in the future of human race. The appeal here is to social interests and social utility.

3. Intellect:

It should give children an introduction to scientific method of thought and investigation. This appeal is essentially one to the intellect and and in so far as it is achieved, science takes the place of mediaeval study of logic. 6

Most of the courses of science in English Secondary Schools, till 1944, centred unduly, round its intellectual and methodical aspects. They had neglected to make provision for the individual and the social interests and utility. Training in scientific method as per the opinion of the Spens Committee, has a special value for pupils who will pursue a life job, dominated by science. But it should be taught to all boys and girls without reference to their future careers. It should be taught as Latin was taught in the middle ages because of its use. It should be taught not as a subject for specialists but as a subject useful to all, as an element in their own life and useful to them as an ~~unavoidable~~ indispensable background of much current thought. Even to the specialist, the formal aspect of science should only be the end-point and not its entrance gate. The above ideas are emphatically elaborated in the report of the Spense Committee.

Courses of studies in Science:

In laying out the above broad policy regarding the objectives of science teaching no doubt, the Spens Committee had in their view the education of boys and girls of England and Wales. This Policy equally applies to the education of Indian boys and girls, as science has begun to permeate through every field of human activity in this country also.

On the above basis the Committee have attempted to lay out the general outline of a science syllabus, and it is of particular interest to us as we have to reorganise our science programme in schools, bearing in mind the scientific needs of the individual and of the society. The Committee feel that the frame work of the science course for general education should be widely drawn such as to provide the acquisition of a body of knowledge on a number of topics and an ability to appreciate the method of science. How are the teachers to select topics to suit the above aspiration from a vast field of accumulated wealth of scientific knowledge? It is essential to bear in mind that while selecting the topics, those topics must stimulate the interest and imagination of the pupils, naturally. This can be achieved only when we select topics within the experience of the pupils. Hence it is desirable to adapt the syllabus to the local environment. It should thereby aim at imparting a knowledge both of physical and biological worlds in which the children live and hence evince interest.

'Under the heading of Physical Science dealing with the physical environment of the children, topics from astronomy, physics, mechanics, chemistry and geology will have to be included. No course of science can be satisfactory unless it includes some ideas of the nature of the earth, its place in the universe, and its relation to other bodies therein. In other words, a little of astronomy is to be taught.⁷ In India, most of the institutions are day schools. Hence there is the difficulty of getting boys for night observations and hence practical work is to be curtailed in that field. Yet the practical work may be limited to day time observation of the sky and the use of the stellar maps. Lantern slides and the use of the epidiascope may be used to give further information about the sun, the planets, the fixed stars

and the nebulae. Geology claims a place next to astronomy in importance, because, it can be dealt with in small campus and as it falls most naturally after astronomy. The children by the time they leave the school, must become familiar with the main geological features of their neighbourhood and should have acquired a reasonable amount of knowledge of the relation of geological formation scenery. No doubt, some aspects of them may come under geography. But, they should be studied either in geography or science. Since it is a subject to be studied in scientific way and certain amount of practical work is to be provided, it is better to treat them under science.

Properties of matter, under physics, claim first place since a knowledge of it is essential for any work in science. Hence, this should be not merely included in science, but should come quite early in any science course. The different and differentiating properties of solids, liquids and gases should enable the pupils to have a first hand experience of the topics like surface tension and fluid pressure. These should lead on to the change of state of matter culminating in the recognition of the phenomena of fusion, solidification, evaporation, concentration and sublimation, together with their application to phenomena in human life. The next topic in relation to the physical environment of the child is the concept of density which can be connected and taught with surface tension and fluid pressure.

Though the subject of mechanics is much suited to be treated under mathematics, the pupils should know the clear meaning of the terms like pressure, force, energy and friction. They should know the fundamental laws of motion leading on to the profitable use of mechanics

by which man can use the natural forces for his advantage. They must realise that no mechanical device exists which produces as much energy as is put into it. This should lead on to understand other forms of energies. Heat, light, sound, electricity may be treated both qualitatively and quantitatively. These topics should be dealt within their relation to everyday application.

Though sound is playing a very important role in modern life particularly in relation of transport and communication, less attention is usually paid for this subject. It may be due to practical difficulty of conducting related experiments. But it should be possible to introduce children to the conception of wave motion and vibration through simple experiments and make them appreciate how these ideas are made use of in modern life. They must have a clear idea regarding the change of energy from one form to another, leading on to the ultimate nature of this universe. The phenomena of reflection, refraction and dispersion may also be included. The concept of wave motion of light may be taught after teaching rectilinear propagation of light. Instead of drilling sums involving U , V and F , the common optical and other instruments based on the knowledge of sight may be familiarised. The significance and utility of the concept of U , V and F may naturally evolve as the end-points of the study of that topic.

Under electricity they should have qualitative knowledge of the thermal, chemical and electromagnetic effects of a current and of their applications in various situations in modern life. Electrostatics and magnetism may be limited to common requirements in every day life and to the understanding of other phases of electricity. Volt,

Ampere, Ohm and Watt may be taught in relation to their application in life. Advanced topics like direct and alternative currents and their differences, principles of wireless, etc., should receive only popular general treatment through lecture demonstrations. The pupils will have to acquaint themselves with the relation between matter and energy, leading on to the study of the energy stored in atoms and the need for harnessing it for the peaceful use of mankind.

The present practice of having an academic course of inorganic chemistry, should give place in general science to a course of general chemistry to enable the pupils to appreciate the fact how man has made use of the products of the earth to his requirement. The experimental study of water, air and combustion must no doubt, claim a place. Minerals and other substances obtained from the earth and their more important properties and uses should be studied. Above all, the pupils should acquaint themselves how the knowledge of those things has revolutionised human living. The process of fermentation and other chemical phenomena that play a direct part in everyday life, should be experimentally studied as in American laboratory schools.

Spens Committee suggest that the topics of biology can be studied from the early childhood. The pupils may learn the names of plants and animals in early period. This approach is no doubt, a natural history approach. Though it is possible to give some local colour to the subject through this approach, it cannot be continued long. Soon the centre of interest should shift to the general characteristics of living beings and the various life processes like metabolism, respiration, sensitivity, movement, reproduction and the interrelation between

the different groups of organisms. The life of plant should be studied and connected to the life of animals. The laws and principles operating in their life must be related to the life of man in the study of human biology. A continuous but carefully graded course of sex education, should be evolved through the courses of study in biology. In still later stages, all topics of treatment, such as to lead on to the sociological problems like food, population and race, should be carefully incorporated. The various fields in which biological knowledge is helping man to improve his living, should be treated though as part of lecture demonstration. The pupils should be enabled to realise that every act, every thought and every feeling they experience, will ultimately contribute for shaping the progressive or the retrogressive features of the future of mankind. This concept of human life should develop in him the sense of responsibility of safeguarding the interest of human race by a devotion to racial consciousness, in the broadest possible sense.

The above course is not a regular syllabus. But it indicates the range of Natural Science. The wide scope is just to mend the present narrow special courses in chemistry, physics or biology and to relate whatever we study, to the life of man. Though the outline suggested above indicates the general lines on which the science curriculum is to be organised, full provision is to be made for local interests and problems. The various topics are to be arranged with due regard to the maturity of the class. The selection of topics should cover a wide range so as to make the pupils realise the full and potential richness of Natural Science in the whole world of phenomena. The principles of selection and organisation of the diverse tupe of materials of

instruction and the principles/^{on} which they are to be correlated will be separately dealt with in a subsequent chapter.

Science makes its best contribution if early specialisation in any one branch, is avoided. Nature Study for the early two or three years may seem to be a suitable course of science. Some may even like to retain it for some more years. Nature Study by itself, is certainly good. But this is inadequate if ~~science~~^{it} does not include some aspects of human activities in the field of science. This is particularly desirable in view of the fact that the pupils will be surrounded in modern life by a variety of the witchcraft of modern machinery, which can easily be understood by a study of science. A wider course of elementary science which can satisfy the all round curiosity of boys and girls, may be introduced for the primary schools. Such a course of general science should be introduced right from the beginning of the school and should continue as such, till the period of 16th year. In the early stage the formal principles of science may not be drilled but its functional aspects may be stressed. The educational system in India is being reorganised and in the new set up such a course of science education is to be ensured for one and all commencing from the primary school and extending upto 16th year.

It is evident from the foregoing, that it is not desirable to allow pupils to specialise in any branch of science earlier than 16 and that it is essential to give them a birds eye view of the wider field of science through general science, before they could settle down to specialise in one or the other branch of science in its formal aspect. This is to state that the study of general science first, and specialisation next, is essential to provide a firm foundation of the former

for the building up of the latter, in the same way as it is desirable to build a peak on a plateau. But the situation is changing in the post-war days in England and other countries. The international competition has prompted every country to step up its industries. This has necessitated the inauguration of early specialisation so that the requisite man-power can be produced for the industries. In the United States of America attempts are being made to introduce a sort of specialisation even at the primary schools in the name of conserving science talents. It is very difficult to say what will be the result of this new trend on the total personality of the developing child. Anyhow this trend will be considered separately in a later chapter.

Some may feel that there will be insufficient time to cover the entire range of syllabus consisting topics from so many branches of science. We may draw their attention to the suggestion made in the Prime Minister's Committee Report on the 'position of Natural Science' in 1919. It is said in that report that much of the time allotted for practical work, may be utilised by the teacher to demonstrate practically, a number of experiments. This enables him to cover a larger ground in, and a greater variety of experimental work. By a greater use of such good demonstrations the Spens Committee also believe, that science teachers can easily and more commonly stimulate wonder and imagination of the pupils.

A course of general science, however rich and potential it may be, cannot contribute to the full development of the pupils' appreciation of the wide horizon of this wonderful universe unless a suitable technique of teaching and guiding is adopted by the teacher. In addition to his lecture-demonstration work, the teacher should also provide adequate opportunity to the pupils to try simpler experiments themselves.

Activity should form the starting point of science teaching. Though certain amount of notes giving is necessary, the pupils should not be tied to the 'notes but nothing else'. This will come in the way of developing their habit of reading books. They should be encouraged to read good scientific books, suited to their interests and the level of their maturity.

If a general science course on such a wide basis as suggested by the Spens Committee, is to be introduced, naturally it is difficult to get teachers. The Committee could foresee this difficulty and hence have recommended that in the University, a wider range of subjects may be offered at the degree level, involving the study of at least 3 branches of science, at least for those who are going to become teachers; then, it might be possible very shortly, to get suitable teachers for the purpose. Nearly, thirty years ago, the Committee expressed the above ideas. We see now, a good number of English Universities have introduced general science as a subject of study for the degree course. The above suggestion is also being implemented in the newly developing North-staffordshire University, though in a different way.

The existing teachers of science should meanwhile, enlarge their horizon of scientific acquaintance by attending courses which are already available or can be made available, either as external or part-time students of the University or the Technical Colleges or Institutes. Special courses in science conducted by the Ministry of Education or organised by the Extension Service Centres or other bodies, may also be availed of. If the teachers are convinced of the desirability of the new general science course they can adopt it in one way or the other and equip themselves with the necessary experience to teach the subject

to teach the subject in its new form.

General Science movement in England:

The general science movement in England largely owes its development to the efforts of the Science Masters' Association. As far as back as 1915, the movement may be said to have commenced when the Association of Public School Science Masters, the Parent body of the School Masters Association, appointed a sub-committee to report the ways and means of furthering the claims of science as a school subject. The chief events that took place later on, to develop a general science course for the secondary schools, may be summarised as follows:

1. The Association of Public School Science Masters drew up the Memorandum on 'The aims of Science Teaching in general education and science for all' in 1916.
2. General Science was discussed at the annual meeting of the School Masters' Association in 1919.
3. An article entitled 'Science for all' with a plea for general science was published in School Science Review in 1920.
4. The S.M.A. Committee prepared a pamphlet on 'General Science' and successfully pressed for the inclusion of general science as a subject for the school certificate examination in 1924. In 1932, this pamphlet was revised.
5. A sub-Committee was appointed to consider the aim, content and method of a course in Elementary Science such as was suggested by the panel of investigators (1924), which had enquired into school certificate examinations. Their report was discussed in the Annual meeting of 1934.
6. A new sub-Committee was appointed under the Chairmanship of C.L. Bryant in 1935, to go further into the question of general science. Their report was published in two parts under the title 'Teaching of General Science' Part I in 1936, and Part II in 1938.

7. A new sub-committee was appointed to review the teaching of general science in the light of the experience gained. But this came to the conclusion that the time was not ripe for the purpose of discussing changes in 1944.
8. The sub-committee was appointed to do the work entrusted in 1944, and it brought out its report in 1950.
9. Report on the teaching of general science was published in 1950 incorporating the latest trends in the field.

Butler's Education Act of 1944 envisaged several new features in the Secondary Education of England. The creation of 3 types of schools that draw three different types of pupils, with three different objectives, is one of its important features. The other is the new system of external examination for grammar and technical schools. As a result of this reorganisation of secondary education there was need for 3 types of science courses.

1. A Science course for those who pursue general education till 16 and leave school or discontinue science at 16.
2. A Science course for those who ultimately specialise in science in the 6th form.
3. A Science course for those who ultimately specialise in other subjects in sixth form but want to continue contact with science.

Keeping the above situation in view the Science Masters' Association prepared a 'Minimum Syllabus' for pupils of the I category including all the essential topics necessary for general education and for taking the examination at 'O' level if necessary at 16. This will also suit the pupils of the II category since they ~~take~~ take science paper only at the advanced level.

The III category is the group of non-specialists science students. After 'O' level, they will specialise in some other subjects but devote 2 periods per week for science (Language and Craft stream). They will cover the same 5 year basic science syllabus in 7 years. If that is the case they must take different papers in general science from ^{those meant for} specialist science students. Hence the science masters have prepared a minimum science syllabus or the basic syllabus for a 5 year grammar school. The course for 3 years is foundational and that of the remaining two years is subject to alteration in accordance with the different needs of different schools and different needs of different sides of a single school.

To exhibit the essential unity of Science some schools arrange their work in early stages at least, around suitably chosen 'topics'. So, the Science Masters' Association in its report on Teaching of general science (1950), has also given a 3 year science syllabus arranged in the topical order. The syllabus is extended year by year, on a concentric basis (page 88 to 95).

The report also gives an extended syllabus for those schools that can devote more time for science in the 4th and 5th form and for those students who want to specialise in 6th form. It is merely extending certain topics (into details) of the Basic curriculum.

Science for Non-science Specialists: III category of pupils:

The objectives of teaching science to non-science specialists are to enable them:

1. to understand the scientific method and its specific contribution to the history of human thought;

2. to understand the historical background of scientific ideas and discoveries;
3. to know the importance of science to the present and future well-being of our society, and
4. to know how to relate science to other subjects.

For such 6th form non-science specialists a science syllabus is prepared (page 104) in 6 parts. Part I consists of history of science; II, III, IV, V and VI parts consist topics of astronomy, physics, chemistry, technology and biology.

The Report also considers ~~considers~~ some problems that have arisen since the introduction of general science. The introduction of broader courses of general science into the school programme where previously two or more of the specialised narrow courses were studied, does involve some problems. Keeping in view the advantages of a broader based course in science, attempts must be made to solve those problems. It is only natural to face such problems whenever new strides are made in the field of education.

It is desirable at least, in the early stages, that all the science work for a given class should be in the hands of one teacher since the essential unity of science lies in its method. It is quite necessary to give some ideas of that method to the future citizen with a realisation of its wide applicability. If more than one teacher were to teach, each his special subject, in its own way, the pupil is likely to feel that there are different sciences, each narrowly confined, and may fail to apply those trainings outside those special fields. Hence at least for the first 3 years of a 4 year

course of secondary education, that unity must be maintained in the teaching of general science.

Another problem is the reluctance of the specialist to teach the topics of other branches of science. He may naturally plead his inability to know the contents and scope of the new branch. In fact, even if he has not studied a branch of science, the topics to be covered in that fresh branch, will not be difficult for him to study and acquaint, before teaching. This will certainly, be a sort of in-service learning! If all the specialists sit together and plan, they will feel the importance of teaching every branch of science. So, frequent meetings of science teachers in each school for planning will help in solving these problems. It will also help them to maintain uniformity in the extent and scope of treatment. Towards the last one or two years, however the pupils may be made known some aspects of specialisation like classification and isolation of types of problems. Though this permits teaching of general science by separate teachers, it should be borne in mind that for specialisation, it is only a development and not a starting point.

Laboratory accommodation is another problem that we have to solve if general science is introduced. This problem will be considered in detail, in a later chapter. The best thing to remember in this connection is that all practical activities, to whichever branch of science they may belong, should be organised in a common laboratory at least for the earlier 3 years. Later, when the increasing complexity calls for sub-division, the experiments, even demonstration lectures, may be held in specialists' laboratories. This increases the demand for more space. It is however, less flexible than other problems.

If there are three streams it is possible to allocate the most suited laboratory to each stream for 1/3 of the term. But this solution may not practically be possible in many overcrowded secondary schools. But if proper planning can be done well in advance, it is possible to equip the very room where they are having classes with trays, articles and other equipment enough for every week or fortnight or so.

The Popularity of General Science Course:

From 1926, there is a steady increase in the number of pupils in general science course in the secondary schools of England. This can be taken to indicate the popularity of this particular science course. The following table indicates the number of pupils taking up the various courses of science for the first examination of the school certificate course during the first decade of the second quarter of this century:

Subject			Number of entries		Percentage	
			1926	1937	1926	1937
1. Botany	..	..	13627	8487	25.4	11.0
2. Chemistry	..	..	21527	27246	40.2	35.3
3. Physics	..	..	13255	20826	24.7	26.9
4. Physics with Chemistry	..		3042	7956	5.7	10.3
5. General Science		..	1340	4779	2.5	6.2
6. Mechanics	..	..	2138	1660	4.0	2.0
7. Heat, Light & Sound		..	2980	2785	5.6	3.6
8. Electricity and Magnetism			1729	2724	3.2	3.5
9. Biology	..	..	86	15119	0.2	19.6
10. Domestic Science or Hygiene			-	434	-	0.6

The above table indicates that the number of pupils taking up part of physics course is substantially decreasing, while that of pupils taking up broader courses in science is substantially increasing. Of ^{the} changing popularity of various science courses, it is to be specially noted that general science course has attracted nearly thrice the number of pupils within one decade. This is true to a lesser extent with biology compared with botany and physics with chemistry, instead of physics or chemistry. Samples of the schemes of examination and courses of studies in general science as prescribed by two of the University Boards, are included in the appendix of this volume.

The statistics relating to the popularity of general science refer only to the pre-war days. Things are now changing mainly, because of the lesson taught by the war on the one hand, and partly, because of the organisational changes brought about by the Butler's Act of 1944, in the secondary schools in England. Such changes are more marked in U.S.A. and U.S.S.R. Since the publication of the draft curriculum in general science by the All India Secondary Education Council, Delhi in 1956, all the states in India are also replacing special science courses in their secondary schools, by a broad-based general science course, so as to ensure a general or liberal education through science. Reference will however, be made in the subsequent chapters to the extent to which an understanding of those changes will help us to improve science education in our country.



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CHAPTER VII

Science Programme in the English Secondary Schools.

The Board of Education in 1904, in its regulations for secondary schools, laid down the broad frame work of the curriculum for secondary education. Those salient articles of the regulations can be profitably borne in mind while considering the problem of curriculum for any grade of instruction. Those articles are:

1. The secondary school must be a school for pupils who intend to remain for four years at least, upto the age of 16. It must provide a progressive course of general education of a kind and amount suited to an age range at least, from 12 to 17.
2. Adequate provision must be made for the instruction in the English language and literature, one language other than English, geography, history, mathematics, science, drawing, singing, manual instruction in the case of boys and domestic science in the case of girls, physical exercise and for organised games.

The above frame work provides a basis for the organisation of courses of studies in the secondary schools. Such a course of study is described as 'general education'. But the term 'general education' may mean anything. It may mean a wide range of subjects instead of one or two subjects; it may mean a training for every future occupation instead of a training for a single job; it may mean development of certain attributes in the pupils, like skill, habits, sentiments

and attitudes of mind as well as the possession and use of knowledge. It may mean every one of them!

Though the curriculum is said to be for a liberal or general education it applies equally well to any type of education between an age range from 12 to 17. It also implies that the education of that period of the child's life should be mainly cultural. This broad outline has helped to bring about a uniform standardised curriculum for the secondary schools. This uniformity was further strengthened in 1917, by the introduction of a single school certificate examination at the end of the secondary school course, instead of a number of examinations. This continued to influence until 1945. As a result, the schools adopted a rigmarole, out-of-date, and uniform curriculum in all subjects, including science, instead of an up-to-date really useful and flexible curriculum. In other words, the curriculum that was in use during the second half of the 19th century for the great public schools, continued to be followed even upto 1940. With regard to science, the wealth of material since then, has considerably increased. The course was framed at a time when civilisation was comparatively static. The last half a century has seen many remarkable changes. The world in which a modern child is born and the world in which he lives and in which he has to live later, is quite different from the earlier world. The advance of technological knowledge in this half of the century is much more greater than in the whole of the previous history of the human civilisation. The old lines of social cleavage are breaking down and a new era of civic consciousness based on universal brotherhood, is in the approach, with its improved method of transport, communication, agriculture, food, sanitation, health why, every field of human life; individual and social living has been

revolutionised. Indeed life itself has become a technical profession in this world of technology. The subject that is responsible for these marvellous changes, is undoubtedly, science. Science as we have seen in recent years, has developed such a potentiality as either to revolutionise human civilisation or to totally destroy it. Then, in order to prepare our children to live in such a technical age, it becomes evident that the curriculum of a static age should be reorganised to suit the needs of a dynamic and technical society of this technological age. It is needless to state, the revision and reorganisation of science curriculum, which is responsible for all these changes should be taken up all the more seriously. While dealing with the work of reorganisation, the following principles of curriculum construction may be of use. In addition to the above sociological factor we have to take into account the psychological factors also. Of those psychological factors that are directly related to the nature of the curriculum are:

1. The principle of transfer of training;
2. The nature of boys and girls regarding their interests, ability and aptitude;
3. The emphasis in the educational theory, that has shifted from the subject to the child and
4. The presence of individual differences between children and children in their aptitudes, sentiments, abilities, inclinations, etc.

Secondary education is rapidly extending in all countries. The number of secondary school pupils in England and Wales in 1911-12

was 165570 or 4.6% of the population. It increased to 11.3% in 1937, nearly to three times in 25 years. It is almost four times at present, or nearly $\frac{1}{6}$ of the total population! This increased demand for secondary education has raised new problems in curriculum construction. A narrow range of Grammar school curriculum, either in science or any other subject, cannot suit the widened range of abilities and interests and aptitudes of pupils drawn from a wider range of social and cultural backgrounds. Further, the usual tradition of the secondary school education to lead on to university courses, had to break down. A number of pupils could not continue more than five years in the school. This could even augment the problems of unemployment at the intellectual front. These two products of the increase in the number of pupils in secondary schools, compelled to think of revising the aims of secondary education as ~~that~~ did elsewhere in the world.

The changed concept of Secondary Education:

During the 20th century, particularly, in the second quarter, there was an unrest about the objectives of a liberal education. In order to prepare pupils for the universities secondary schools had to teach a number of subjects, which were later use~~less~~ in the pupils' life. Further, it was a mere acquisition of knowledge than development of personality in terms of skill, attitude, taste and feeling. They included subjects that were of no use to modern civilisation; they did not take into account, the requirements of the present day world. The pupils had to adjust to the rigid examination dictated curriculum and there was no scope of adjusting the curriculum to the needs of the pupils.

their interests and abilities were disregarded. Individual differences were not taken into account. Above all, to master the rigid curriculum with the only objective of entering the university, was a heavy strain on the pupils particularly, on the average and the backward pupils, at the most delicate age of adolescence. These facts are reflected in the report of the consultative committee on 'The Differentiation of Curriculum between Sexes in Secondary Schools' in 1923. Their verdict with regard to girls, equally applies to boys. This naturally, forced the educational world to think of alternative objectives of secondary education taking the actual situation into account.

The Changed Objectives of Secondary Education:

No doubt, the objectives of education of the grammar school were quite clear. Those objectives were to train the pupil as a person with a body, a mind and a spirit, and to train as a future citizen of the democratic country and to train him as one who will have to do work of some kind or other to earn his livelihood. These objectives are also aimed at by the other newer secondary schools. This is reflected in 'The Handbook of Suggestion for Teachers' published by the Board of Education, in 1937. It says that the aim of education should be to develop the potentiality of every child at school in accordance with the general good of the community of which he is a member. This implies to develop the child's abilities and potentialities, both in his interest and in the interest of the society. Hence, it must be a complete education both for those who go to the university and others who want to go for other higher studies or get employed in a job to start life direct. Hence it is necessary to formulate the principles of

curriculum construction keeping in view all these changed aspects of life.

The Concept of Curriculum:

The curriculum of a school is a statement or programme of teaching and instruction. It consists of a diagnosis of contemporary life and instituting its cream within the frame work of the institutional life; but the newer ideas have entered into the school curriculum from several distinct sources. Some may have come down as such from ancient institutions. Some are evident and direct response to the needs of an age which has seen immense development in the field of industries and politics in all nations. Other ideas are profound modification of the old. But their expressions and changes in sentiments require the school, to accept responsibility, formerly born elsewhere. The advance in the technique of education with an incessant discussion of ends, ways and means, has made the subject extend beyond the interests of teachers and administrators.² Rather, it has become the concern of the entire community. As a result of all these additions and influences a typical school of to-day, has become not a mere 'place of learning, but a social unit' in which the younger and older, the teacher and the taught share a common life to the constitution of which all submit and pursue purposes that are correlative though not coincident. Such a society should not be pervaded with artificial sentiments. But it should be natural such as to facilitate older members exercising due influence upon the growth and character of younger members. It must also permit the younger members to enjoy the space and freedom for achieving their many sided development. In such an organisation of childhood the curriculum should be formal and retain the central place while other activities should be less formal and make essential contributions to the total life of the

school society. This concept of the curriculum, as a result of the developing concept of education, is gradually expanding to include the entire institutional programme, whether formal or less formal.

Education fundamentally, is the practical philosophy of life. Hence any aim of education should reflect the ideals of life. These ideals will of course, be changing. Thus they bring in conflict in the objectives of education. But yet, it is necessary to note the various bodies that are related to these objectives. The community with its established machinery namely, the state, wants to maintain the nation's cultural integrity from generation to generation. The community wants its members, one and all, to preserve its specifications, and a few others to contribute for its progress. The present day democratic community further wants to educate its masters; it desires that the young shall grow up in conformity with the national standards.

The parents who influence the growth of child to a very great extent, wish their child to acquire a standard of discipline and culture and expect him stand on his legs after the school days and take up their own place as a young partner in life.

The Changed Position of the School:

The above transformation has made school into a society; the children take to education willingly. This is not because there is no punishment, not because there are modern and easy subjects but because the school is the place where they can satisfy their natural urge - physical, intellectual, social and moral. In the Board of Education's report on 'The Primary School' it is stated that though primary school thinks of preparing boys and girls to the secondary

schools it shall also think of providing opportunities for satisfying their present needs and to develop their intrinsic values.³ The more perfect these immediate aims are achieved more perfect will be the later objectives and further intellectual growth. This statement will equally hold good in the case of secondary schools. In addition, the school should provide for the early and later adolescent years a life which answers to their special needs and brings out their special values. So, there is no meaning in looking to the College needs only in the education of a secondary school boy. It must provide such an opportunity to our boys and girls as to develop their personality to the fullest extent regardless of their possible entry into the college courses. It must be an education, complete by itself.

From the community and the state, from the parents, from the teachers and from the nature and nurture of boys and girls issues the pattern that is to shape the school society. The difference between one school system and another and between one school and the other among the same type of schools, are due to varying prominence of those forces of influence. This is indicated by the variety of schools in England due to varying amount of freedom as against uniformity in the continental countries and India due to a system of rigid central control. But the needs of a university examination, needs of a homogeneous society have influenced to a great extent towards a healthy uniformity amidst that diversity. Both these two features namely, uniformity and diversity are no doubt, desirable features in themselves but have limitations of their own. These specialities and limitations are to be taken into consideration in weighing the

curriculum of a school. However, the purpose of the school is to foster the growth in every boy and girl, to achieve the highest degree of development of which he or she is capable. But we have to bear in mind that such a development can best be developed in a social medium. It is in the light of these declarations that the curriculum of the school is to be applied.

What Experiences to provide ?

While legislating for a society, while indicating its scope and nature of its activities through a curriculum, we must take into consideration the pupils' physical, intellectual, moral and social development, while reflecting what is best in the life and traditions of the community. While studies should not be such as to be beyond their present comprehension and experience, it may be said that in the later years of a school, certain studies with definite bearing on the next stage of their life should be introduced, whether that next stage is an occupation, a higher study or a university course.

The intellectual and other activities of the curriculum must represent or reflect what is of highest and most permanent significance in the life and traditions of that community. Certainly, such national traditions apply in their best to the humanity at large. But to give a concrete shape to the curriculum of a school, the traditions of the bigger society should serve as model to the school curriculum. Like the continental countries, England has a strong national tradition. This national tradition no doubt, has been influenced from time to time by various revolutionary elements in the society. To-day, the national tradition has evolved into a homogeneous composite body much different from the earlier one. This in turn, has shaped a society of nation

that has newer aspirations with newer potentialities. Science and technology have played the most dominant role in shaping newer faces of the tradition. The curriculum should conform to these traditions of newer national aspiration and foster those newer potentialities.

The above formulation means that the curriculum of our school should reflect the activities of the present community. These activities are of two types - conservative and creative. The former secures the community's continued existence and maintains its standards of life. In other words, they are the activities that go on in factories, offices, households, on farmlands and in village cottages. The latter are clearly exemplified by the activities of poets, dramatists, painters, musicians, men of science, inventors, technicians, technologists, administrators and legislators. The difference between those conservative and creative activities are not ultimate. Their routine performance of to-day were the creative achievements of yesterday, and may have been the highest creative achievements of all time.⁵

The bearing of the above facts, on the problem of curriculum is direct and important. The school, if it were to reflect the activities of the great society, must give both the knowledge and training required for the routine duties of the adult life and foster the creative impulses needed not merely for the new enterprises and adventures but also for daily adaptation of routine and technique to the changing situations. At present in the secondary schools, the pupils are assimilating too much and do too little of creating. Further, the schools stand too long on ancient ways and are out of touch with modern movements.

It is evident by the foregoing, that the activities richest in

creative element, have the strongest claim in the curriculum. It is they that form the activities noticed in the main lines of human achievements.⁵ It does not mean that we should divide the school curriculum into conservative and creative groups. There can be no such groups. It means that every subject should be so organised that both these elements are incorporated. The relative prominence does not merely depend upon the nature of the contents but also upon the teachers personality, mode of thinking and approach, types of provisions for pupils' initiative and activities, and upon the technique of treatment. No doubt, in the accumulated wealth of human experience, it is difficult to tell which of it is conservative and which is creative. But, if a pupil is merely told it is conservative and if he is guided to realise it, it is creative. The curriculum can provide for the development of pupils' initiative in several new ways and all those activities are really creative to those young people. Hence a larger place should be devoted in the school curriculum for such creative activities than hitherto provided. Such courses of study as the training in the care of health, bodily efficiency and grace, manners and social organisations, handicrafts with emphasis on aesthetic or constructive aspect, should form part of the curriculum. Science should provide in addition to conservative assimilation of organised knowledge, such creative activities as to make use of the principles and formulae learnt, in their functional relation to problems of life. Hence, science programme in any school should naturally, include in addition to pupils' laboratory activities, a number of other organised activities in which the principles of science are exemplified.

Preservation of the Unity of Knowledge:

The present tendency in the secondary schools to allocate separate compartments to narrow fields of knowledge looks artificial. The

division of some social experience of mankind into history, geography, civics, moral lesson etc., simply splits that beauty of unity. Rather it should be studied as one 'social study'. Similarly with science. When it is studied as separate parts, it is difficult to conceive its relation to life. A broad grouping of subjects not merely reduces the load of subjects but gives broader basis for human experiences and greater scope for treatment. It also helps to conceive the general nature and spirit of the subject, particularly in the way in which its impact is felt in life.

Need for a Historical perspective:

Whatever the curriculum may be, its contents, methods of teaching and the devices to be employed, depend largely upon the ability and the interests of the pupils on the one hand, and the needs of the locality in which they have to live as individuals on the other. Further, each one of the above aspects of education, change from time to time in accordance with the change in the ideology and the underlying way of living. The structure of the present position by itself, is less meaningful and less significant than when it is viewed in its historical perspective. Hence before considering the science curriculum of the English secondary schools, it is advisable to study the historical profile and the present nature of the English secondary schools and the type of responsibility they have developed through ages and the type of pupils that they undertake to educate at present.

The English secondary schools are not started as items designed at one stroke at one time with one purpose. Rather, they are the products of gradual evolution as a result of centuries of experimentation in the most indigenous manner. It is to be recalled here that the secondary

education like any other aspect of English education, is least influenced by outside forces. Hence, it becomes all the more necessary to study the historical aspect of English secondary education for the full appreciation of the unique position it has provided for science in its curriculum.

England has a long tradition of secondary education. It commences with the establishment of Public Schools in the 16th century. No doubt, some of them are as old as the Hellenistic or the Roman schools of rhetoric like the Public Schools kept by Quintilian at Rome. But most of them appeared in the beginning of the 16th century. Public Schools of Shrewsbury, Christ's Hospital, Repton and Rugby were founded in the 16th century. That of Winchester dates from 1382 and that of Eton in 1440. In addition to these endowed Grammar Schools, a number of less famous Grammar Schools were started before 1500. These schools were intended for the education of the classes. They provided a type of education described as liberal education. They taught the trivium (Grammar, Logic and rhetoric) preparatory to the study of quadrivium (arithmetic, geometry, music and astronomy). Character building and education for leadership were their two cherished objectives.

In the early 19th century, there was an urge towards widening the scope of studies in the Public Grammar Schools. This urge came from within to suit the changed needs of the society. Dr. Arnold of Rugby (1828-42) widened the curriculum of his school. New public schools were founded. They were all endowed and there was no state provision for public secondary education. In 1894, Bryce Commission was formed to suggest a system of well organised secondary education for England.

and Wales. The report of this Commission formed the basis of development of English secondary education in the 20th century.

A 20th Century effort:

The establishment of the Board of Education in England and Wales gave impetus for the big developments in the field of secondary education. Till then, there were three types of publicly aided secondary schools. They were the Endowed Schools, the higher grade elementary schools and the Science and Art Classes. Till then, the local education authorities were not permitted to spend for secondary education. The act of 1902, empowered the local education authorities to encourage but did not compel to provide higher or secondary education out of the rates. Yet this act became the corner stone of the state educational system in England and Wales. It abolished the school boards and made the County Councils, County Borough Councils and certain Borough and Urban district Councils, the educational authorities. It gave County Councils and County Borough Councils power to supply or assist supply, education other than elementary education. It also empowered them to give grant to voluntary schools in return for control over the instructions in those schools except over religious instructions. Experiments started in post primary education.

The act of 1902 paved the way for the rapid development of secondary education in the country. The Fisher's act of 1918, further consolidated the secondary education. It raised in addition, the age limit of compulsory attendance to 14 and without exception, to the end of the term. This necessitated the local education authorities to provide advanced education to older pupils in senior departments or central schools. A number of Local Education Authorities organised

separate schools for pupils above 11. Till then, education in the secondary schools was not free. This extension of educational facilities to older students, resulted in the organisation of instructional facilities in the different subjects. It particularly helped to develop a science programme for boys and girls, up to the age of 14, including facilities for pupils' laboratory activities.

Hadow Committee Report, A land mark:

Though a number of secondary schools were started after the Act of 1902, and a variety of experiments in post-elementary education were in progress, the term elementary and secondary were left undefined till 1926. A Committee set up under the Chairmanship of Henry Hadow, issued a report on 'The Education of the Adolescent' in 1928. It recommended among other things:-⁷

1. That all education after the age of 11 should be known as secondary education.
2. That there should be differing types of secondary schools designed to meet the varying needs of different types of pupils;
3. Pupils should be moved from one type of schools to another at 12 or 13 if they are likely to profit. and
4. That the compulsory school leaving age should be raised to 15.

The Hadow Committee Report proposed a complete break for all children at the completion of 11. For 13 years after the publication of the Hadow report there was a reorganisation of the English schools. Inspired by the suggestions of the report and backed by the Board of Education, the Local Education Authorities provided adequate facilities

for the education of children after 11. More central schools and senior elementary schools were built until 1939 when the second World War put an end to it. A process of trying and testing the science programme to suit the varying interest of children was taking place.

The Spens Committee Report - the turning point:

No doubt, there was a steady but confused growth of post-primary education after the publication of the Hadow Report. There were the grammar schools with well established traditions. They were the real secondary schools. But the Modern Schools that provided education after 11, were also secondary in nature. But, they did not enjoy the same prestige as the grammar schools. There were also a number of technical junior schools. Even they were not able to gain the prestige of the secondary schools. But there was need for making all types of education after 11, equal in status. Hence a new committee, with Spens as its Chairman, was set up to consider the matter. The committee issued its report in 1938. It suggested among other things -⁹

1. That whatever the type of education may be, the school after the age of 11 should be called a secondary school.
2. Three types of schools may be started in accordance with the differing ability and aptitude and needs of children.
3. All may enjoy the status of secondary school.
4. The secondary grammar, secondary modern and the secondary technical schools may be started to provide education after 11, according to their ability, interests and needs.
5. A course of general science should be taught in all secondary schools upto the age of 16 as part of a liberal scheme of education.⁹

The Spens Committee's recommendations could not be given effect to, as the country plunged into the second world war, the very next year. During the war time the nation realised the importance of a sound system of general education to one and all in the country. The suggestions made by the Spens Committee, particularly those connected with the strengthening of science programme, were realised to have far-reaching effects when implemented. In fact, those recommendations were implemented to a great extent by the Act of 1944.

1944 Act - Diversification of Courses:

The Hadow Committee report postulated three types of pupils in the post-elementary schools. The first type of pupils who will study beyond the 16th year and take up some university examination, proceed later to university studies or other higher studies. They are pupils gifted, more fortunate and suited for an academic type of education. The second type of students are those less gifted but who study up to or beyond 16 and take or not take, a university examination and proceed to some higher technical course or join industry. They are the technical students. The third type of pupils are those who are least gifted and least fortunate and likely to stay up to 15 only and do not wish to take up any examination but settle in life immediately after 15. They are the modern students. The Hadow Report recommended that all these three types of pupils should study in a secondary school suited to their ability and requirements. Further, the Committee after an analysis of the social need, referred to the fact that the first group will have to become the technologists and the second group the technicians whereas the third group to become skilled labourers and good citizens. The Committee also examined a number of witnesses psychological, industrial and sociological. On the basis of the

evidences it recommended three types of alternative secondary schools, each equal in status with the other but designed differently so as to provide the best type of education suited to each stream of students, after the primary school. These changes envisaged in the report, could only be given effect to after the second world war, in 1944, through an Act of the Parliament.

In the field of secondary education the most important changes made by the Act of 1944, are these:¹¹

1. Secondary education was made available to every child without cost to the parent over 11.
2. From April 1947, school attendance was to become compulsory upto 15. As soon as possible the minister might raise it to 16.
3. Secondary schools should be separate from primary schools except for disabled children.
4. Detailed minimum requirements were laid down regarding the school buildings, qualifications of teachers, size of classes, etc. These requirements apply both to schools provided directly by the local education authorities and those by voluntary authorities. In the latter case the local education authorities or ministry of education would pay the entire cost of education including teachers' salaries and improvements.
5. Public funds were made available to voluntary agencies under certain conditions to play their part in the new scheme of education.
6. Every local education authority was empowered to supply or aid to supply the full education in its area-primary, secondary and 'further' education. Formerly there were some authorities having control over primary education while a different authority was responsible for secondary education.

The above changes created for the majority of children completely a new educational service.¹² It was possible to design and evolve different types of science programmes for each type of secondary schools in accordance with the differing nature of pupils' ability, interests

and needs.

different types of Secondary Schools:

The education Act of 1944 is based on the principle that 'Schools must differ in what they teach and how they teach it, just as pupils differ in tastes and abilities'. The secondary school system naturally offers variety in the curriculum and variety in the approach suited to the differing aptitudes and abilities and stages of development of children, concerned. Moreover the school life of some children will be longer than that of others. As stated earlier, secondary schools had to be planned to cover six to seven years in case of those desirous of going to University, while for those who do not, will have to be planned for four or three years. Yet all schools should be so designed as to provide a complete education. The recognition of these facts is a special feature of the 1944 Act. It requires secondary schools to be 'sufficient in number, character and equipment to afford for all pupils, opportunities of education, offering such variety of instruction and training as may be desirable in view of their different ages, abilities and aptitudes, and for the different periods for which they may be expected to remain at school' (Section 8, (1), 1944 Act). Clearly, it was necessary to have a wide variety in the secondary system. The curriculum must be made to fit the child and not the child to the curriculum. Schools must offer the kinds of curriculum that will fit them all to live happily and to become useful members of the community.¹³ The above requirement of the act, as will be seen later, is the single impetus that prompted the secondary schools to evolve a variety of science courses, suited to the varying interests, abilities and needs of pupils.

There are certain boys and girls who learn most easily by dealing with concrete things in technique common in their day-to-day experience.

At 11, a few of them could disclose particular interests and aptitudes, well enough to require any other course. They would like to develop freely in their own line and get an all-round education. Such a school will also provide them opportunity to sample out their skills and subjects and to pursue those which attract them most. This type of pupils forms the majority of secondary school children at 11+ and it is for them the secondary Modern schools have been designed by the Educational Act of 1944.

Some students will have decided to make their careers quite early, in branches of industries or agriculture; they require a special kind of aptitude in science or mathematics. Others may need a course more specialised, more exacting and longer in duration than that provided in the modern school, with particular emphasis on commercial or vocational subjects, music or art. It is for such pupils that the Act designed secondary Technical schools.¹⁴

Some pupils whose ability and aptitude require the kind of course with the emphasis on books and ideas, are attracted by the abstract approach to learning and prepared to stay long enough to benefit from the VI form work, which shall form the characteristic feature of such schools. For them the Act designed the secondary Grammar Schools.

The Best Type of Secondary Education to every child:

In fact the schools are designed on the principle that some children possess more of verbal ability and the others have vocational ability based on Alexander's theory of intelligence. But the Act does realise that books are as much essential to the all-round education of any type of child, as activities. Hence, no school can exclusively base its work on only one or the other. A person who has not developed

the skill of his ~~hand~~, is as imperfectly prepared for life as one who cannot read. A person who does not know how to repair an electric bell is as illiterate in life, as one who does not know how it works! The proportion in which these two ways are to be combined, should be determined by the capacities and needs of the individual pupil. A pupil who is going to become an ordinary factory worker, need not be compelled to study the abstract principles of science. Similarly, a pupil who is destined to become a designing engineer, cannot be denied the discipline of an enriched course of science. And the principle involved in the new secondary education is that whatever his native ability may be, the child must be guided towards the kind of work in the school over which he can acquire some sense of mastery. This further means, for instance, that it is of little use to present subject matter to him which he is unable to appreciate or press him to labour in an atmosphere of frustration. It is evident that it is unfair to expect him to develop through a study of Latin or advanced mathematics if he shows no sign of attaining any standard in them. Similarly, it is unfair to restrict him to practical work if his more characteristic outlet is through humanities. No organisation can or will adequately meet the situation that involves the sacrifice of the best interest of one type of child to those of others. No country can afford this sacrifice, which takes the form of a serious educational wastage.

Every secondary school of whatever type it may be, must be able to provide for the full development of the child's personality as designed by nature. This is the vital part of the new concept of secondary education for all. The act also provides for combining in one, wherever possible, all the three types of secondary education. Though this

suggestion can meet both for and against, it is at least essential to ensure that the courses provided, are sufficiently varied to meet all needs and that they are of equal status so that transfer from one to the other is facilitated and that the opportunity is given to all children, the less able as well as the abler, to develop fully and to gain some experience of responsibility. For this purpose it is essential that the school must be sufficiently big to provide necessary variety for the senior pupils. Such a school must at least have a strength of 1500 to 1700. Such schools, in fact, have developed in recent years in the different parts of U.K. under the name, Secondary Comprehensive Schools.

The adoption of the right of children to get education according to their ability, interest and need involves the provision for a country-wide scheme of diversification through a selection examination. However best the selection machinery might have worked, there is likelihood of some wrong or misplacement at 11+ and hence it shall not be considered as final. Moreover, some pupils may have dormant abilities and interests which may develop a little later. Hence, there should be arrangements to reassess the abilities and aptitudes of such late bloomers at a later date and to transfer them from one school to the other if their real or late abilities and interests warrant. Then only can the spirit envisaged by the Act, can be realised fully, in practice.

Though there is need to ensure suitable difference in content, technique and approach to the teaching in the three different secondary schools, it must also be remembered that there shall be a very common feature namely that the education provided for the children in any school, a modern, a technical, a grammar, a bilateral or a multi-lateral or comprehensive, should appeal to the interests of the pupils and related

to their abilities and needs. They must be able to leave the school at whatever age it may be, as balanced individuals, ready socially, emotionally, physically, spiritually and intellectually for the next stage in their lives.¹⁵ This demands the designing of courses in science and other subjects, several sets, each capable of ensuring complete education in that particular field.

A New Orientation to the Old:

Though the Act of 1944 designed three different types of secondary schools for England and Wales it did not create them for the first time. It rather gave a new name with a clearly designed shape and policy, to the institutions that already existed since 1902 or even earlier, in the country for post-primary education. But the only institution that was known as secondary before that Act, was the grammar school. The particular variety of education they offer hereafter, will be only a small part of the secondary education. Those grammar schools were modelled after the tradition of the Public Schools of England and hence enjoyed a long tradition. Since their tradition is sufficiently old, the standard they had already achieved helped them to maintain for themselves and give to the newer secondary schools a sense of direction. Hence it is essential to consider them first before going to deal with the newer ones.

The Grammar School

The grammar schools before 1944, offered a general course for 5 years and stress was laid on logical and academic aspects. Languages (classical and modern), mathematics and science were given a predominantly academic development. The subsequent intensive course in VI form covering a narrower range of subjects, used to lead boys and girls to

studies at the university level. The distinguishing features of the above two courses are to be found not so much in their content, but in their length, in the scholarly treatment of their contents and in the stern intellectual discipline they afforded.

The Norwood Report [page 6 and 7] mentions certain qualities necessary for a grammar school child. According to the above report, they must have a high measure of general intelligence to wrestle with intellectual, abstract problems in a disciplined way. They must also be fond of books and must be readily drawn to abstract ideas. Above all, they must be prepared to stay long enough in the schools to derive real benefit from the studies they undertake. Within the range of talents and interests manifested by such pupils, the grammar school will find scope for the many sidedness on which it has set high values.¹⁰

Though the Act of 1944 has retained the name of the grammar school as such, it should be realised that it did influence them to reorient their policy and functions in a more desirable and democratic direction. Grammar school education was costly; only those who can afford could go there. Of course, a few free places were reserved for those who could come by merit after taking the selection examination at 11+. Yet, there was no scope for the greater majority of highly intelligent but poor pupils to go there. They had to think of some sort of post-primary education though they were fit to become first rate technologists. This was a great waste of national intelligentia. The Act made secondary education free to all. Grammar schools had to admit not merely pupils who are socio-economically fortunate but also those that are intellectually fortunate. In fact, even if a child were to

be rich if he had no sufficient intellect and talent he could never get into the grammar school. This democratising influence not merely provided education of an academic type to all those that did deserve by their ability and aptitude, but also raised the other secondary schools to the same status and standard. Further, since grammar schools were classed with other secondary schools and charged with the functions similar in status but different only in nature, there is need for them to adjust to the life for which they cater. No doubt, in compelling them to respond to this new obligation, they must be allowed to retain their freedom. If this two-sided adjustment were to be achieved the remaining part of their adjustment to aims and method will automatically follow. The Act expected grammar schools to reorient their task within their boundaries with imagination, courage, faith and thought.

The tendency of pupils to stay on after 15 till 18 i.e., for two more years is gradually growing. In other words, secondary education is resolving into two graded courses. It is felt essential to make both courses one continuous course of six or seven years duration. In fact, the special feature of a grammar school lies in its sixth form at present. This is particularly true with respect to specialisation in science and other subjects. Because, in the early stages the courses in all subjects are broadly based as in other secondary schools; and later, in the sixth form narrow specialisation commences. This can be well compared with a tall and narrow pillar of advanced work standing upon a broad and low base of general studies.¹⁶ So, there is the conflict between the interests

of wider studies and the specialisation. Of course, the Act provided for a broad-based study for four or five years and a fairly broader specialisation in the latter years. This is possible only if they reorient the content and technique in a more flexible way. The grammar schools will have to break with the past in some ways. In others, their very tradition will be their strength. 'They have to face the future with confidence and courage on the one hand, and an added sense of responsibility on the other' (The new Secondary Education).

Courses of studies in Science in Grammar Schools:

In all grammar schools there is a general science course for the first two years. In some schools it extends up to the first three years. In a few schools it is carried on up to the 'O' level examination. Specialisation generally begins after the second year. In some schools it may begin after the 3rd year. In a few schools it begins only after the 'O' level examination. After the 'O' level examination the pupils enter the 6th form. Those who take up science, specialise in one or two branches of science. Some of the examining bodies have provided for a course of General Science (Bristol University Board), even for the advanced level of the general certificate examination. In some of the schools there is a course of Natural History which is generally carried up to the 'O' level of examination. The Combined Examination Board of Oxford and Cambridge Universities has provided for such a course.

Pupils in the grammar school are generally streamed out on the basis of their interests and abilities in the 3rd year. They may be

like craft stream, language stream and science stream. From 3rd year onward the craft stream and language stream will have a general science course where as the science stream may either take up an additional general science course or specialise and take up physics with chemistry or physics or chemistry, general science with biology or botany. After the 'O' level, general science is not encouraged in many schools.

Statement showing the allocation of time for science instruction in a grammar school:

I Form - 5 periods of 40 minutes each.

II Form - 4 periods of 40 minutes each.

III Form - Diversified courses:

i. Craft stream - 5 periods of 40 minutes each

ii. Language stream - 4 periods of 40 minutes each

iii. Science stream - 5 periods of 50 minutes for
physics with chemistry;
4 periods of Biology; 9 periods
in all.

IV Form - same as III Form.

V Form - same as IV Form.

(upto VI Form, double periods of 80 or 90 minutes are provided.)
VI Form - i. Lower: 7 periods of one hour each.

ii. Higher: 8 periods - 3 periods come continuously.

(Upto the VI Form, there is no differentiation of

Science course into practical and theory. In the upper sixth, periods for practical and theory work are separately allotted. For practical work three periods come together.¹⁷



The syllabus in the general science course contains topics of various branches of science like physics, chemistry, botany, zoology, geology, astronomy and meteorology. The subject is supposed to be treated with an emphasis on its cultural and utilitarian aspects so that it will form part of pupils' general education for life. Even the organisation of the topics is generally either on a topical basis or on any other convenient basis. It is not generally organised systematically so as to give an academic bias. Whereas the specialised courses in physics, chemistry, biology or botany and zoology are generally, systematically organised with an emphasis on academic aspect.

Another important feature of the grammar school science course deserves attention. In every grammar school there will be many students who will specialise in one or the other branches of humanities and will not specialise in any branch of science. But, it is essential that they also have to study science though they will not take up that subject for examination. A special course of science is provided for such non-science specialist students. This course is generally called "Science for non-science specialists". This is introduced immediately after streaming out takes place in the 13th or 14th year. Till then those non-specialist students would have studied some science in the form of general science. The science for non-science specialists is after all, a continuation of the general course. But now the emphasis is primarily on cultural and social aspects. It is intended to provide them a knowledge of the methods of science, its effect on modern civilisation and the contributions

of the heroes of science to the progress of human thought. Certainly, it is a good background to the study of any of the humanities. It makes at the same time those students of humanity more scientific!

Grammar schools are specially known for their sixth form tradition. Till then the instruction given does not differ so much from that of any other secondary school, though marked stress is laid on academic aspect as demanded by the university entrance requirement. This is particularly true with the teaching of science. The courses of studies in science for the 6th form are specialised and systematic. Each of the special subjects is built so as to give a thorough grounding in that particular field of science to ensure deeper scholarship and discipline needed to carry it on in the University. The syllabus in each branch of science includes in addition to theoretical aspect, a good number of topics for practical treatment to ensure that the pupils will thereby, develop not merely a systematic scholarship in the subject, but also acquaintance with the particular technique of studying the topics.

Some of the grammar schools, particularly the boarding schools have an interesting science course which even to-day, bears the historic name of 'Natural History' course. No doubt, during the last century a number of secondary schools were teaching this subject. It may cover zoology, botany, geology and astronomy. Much of this course is practical work. The students will have to study the flora and the fauna of the selected locality; they have to study the geology of that place. Of course, they do require the guidance of the teacher. This course is not encouraged in other secondary schools. Even in

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those grammar schools where it is introduced, only a few students will study it. Since it is not an examination subject, some times it becomes an optional course. Of course the Combined Examination Board of Oxford and Cambridge Universities has offered 'Natural History' as one of the subjects for its 'O' level examination. But rarely pupils take up that course for their examination.

The Modern School:

The modern school is compared to a growing tree with strong roots but so far, with a limited number of branches. In fact, there are only a very few schools which represent the standard for other modern schools in curriculum conditions, building and the rest of the school tradition. Some of the important factors that have come in the way of their building a strong tradition, are unsuitable premises, lack of stability in staffing, lack of adequate number of graduate teachers on the staff, classes of forty or more and the leaving age of fourteen. But it is sure that the modern school shall evolve a tradition of its own. The line of its development is already clear. That tradition is democratic, realistic, moderate and modern.

The modern school differs from a grammar school in its broad outlook and objectives. The pupils that are entrusted to its care are children of widely differing ability, aptitude and social background. It has to cater for the needs of boys and girls with a marked practical bent; it has to tackle the special problem of backward children. As it is said in the Spens Committee Report 'By no means, all who succeed in commerce or industry are of the type which benefits at all obviously, from an academic and scientific education, and

it is very probable that many such men would have gained more from the curriculum of a modern school, especially if they were more attracted by such a curriculum and more industrious in pursuing it'.¹⁸ In addition to such gifted children a number of educationally sub-normal children, will also attend the modern school.¹⁹ Since the school caters for such a wide variety of ability the modern school will have to work out syllabuses and methods for each type. Naturally, no uniformity in standard, technique and syllabus can be expected. No doubt, the aim of modern school is to provide a good all-round education. The varying interests and abilities of children demand a curriculum that is not of a set, traditional type. It must be rather, such as to appeal to their interests, stimulate their ability to learn and will teach them to pursue quality in thought, expression and craftsmanship. In fact, the school life must be such as to interpret the modern world to them and give them a preparation for life in the widest sense, including a full use of leisure. It will have to aim at getting the most out of every pupil that he is capable of; ~~it~~ it must train him to become adaptable so that he may do any job properly and thoroughly. It shall also be such as to inspire him not to be satisfied with bad workmanship but to be exact in what he says and does. In fact, to teach such pupils with such broader objectives, the school should enjoy in all fields of activities, a good lot of freedom and flexibility.

It is gratifying to note that the modern schools are already building a tradition of their own. They are evolving a balanced curriculum with many kinds of practical activity. They are achieving

a standard of efficiency on the one hand, and dealing successfully with the backward pupils on the other. If the local education authorities were to have confidence in the work of the modern schools and give the same amount of freedom, equipment, staffing etc., as they provide the grammar schools, they can soon become the assets of the national system of education. The teachers of the modern school should have not merely knowledge and experience but also facilities to experiment and adapt their own approach to the varying needs of pupils with whom they have to deal. There is no examination of an external nature. The teacher should be free to vary the curriculum purely on educational lines, to ensure best possible conditions for each pupil to grow and to ensure that the interest aroused thereby, would be kept up throughout their life. The absence of an examination at the end of the course enables the modern schools to adapt themselves in their courses of studies to the particular needs of the community.

The industrial revolution has helped mankind in raising the standard of living. But automation and rapid industrialisation have come in the way of artistic perfection of a master artist, simplicity of life, sense of appreciation etc. The modern school is charged with the special responsibility of giving back those things that are being lost, through a process of all-round education of its own. Religion, physical education and aesthetic subjects must play an important part both in the time table and in the general life of the school. Parents may dislike modern school because, it does not pay exclusive attention to make pupils to 'learn to use their brains'. Because, the purpose of the modern school is to give an all-round education which was not done by earlier schools. Further, it gives equal importance to other functions also, it gives to the use of the brain.

Pupils of the modern school exhibit wide range of ability. Hence, there is great difference in the nature of intellectual training in this school and the other secondary schools. Some pupils are backward and require an extremely simple presentation of the subject matter. The able children require a more ambitious curriculum and treatment for their full intellectual development.

The class rooms, activity workshops and play grounds are all interrelated in their educational contribution towards the whole development of the children. Even with regard to curricular instruction, there is no need for water-tight compartmentalisation. One may overlap with the other. In the lower forms specialisation is not desirable. This must be postponed as far as possible, to the upper classes. English, mathematics, history, geography and science are among the subjects to be taught. Physical education, arts, music, handicraft, housecraft and various other crafts take the activity side of instruction.

Science in the Modern School:

Education in Britain is a partnership between Ministry, local education authority, managers and governors of schools and the teachers. The head master or head mistress is responsible for drawing up the syllabus for each subject in his or her school. They may get advice and guidance - possibly criticism but not directions from inspectors. But the subjects to be taught, time to be spent on each of them and the technique to be followed in teaching them are matters to be decided by the school itself. So to speak, the internal of education is left

to the school itself. The ministry can only guide. Naturally, there is perfect scope to organise the school life in its ~~own~~ way. It is free to select and organise the contents as it feels desirable. Regarding the science to be taught in a modern school, the courses in science are being designed to give pupils some understanding of the laws of nature and some grasp of the scientific achievements²⁴⁰ of man. Thereby, it will arouse their wonder and stimulate their curiosity. It may encourage a scientific attitude of mind. The most effective way of achieving these ends is the adoption of an integrated syllabus of general science, that combines in a coherent scheme a wide variety of topics, covering the whole range of natural science. Biological studies and those dealing with the inanimate world should be included in all schools. Topics for study should be selected for their intrinsic importance and interests and not because they fall within the conventional branches of the subject. In rural area there may be an emphasis on biological studies. City area may lay emphasis on physical sciences. But in ^{There is} either case, no need to concentrate attention on any one branch. Both sides must be studied in both areas. They should remember that they study not about any one area only but about the world. Those areas of experience may draw materials from any branch of science.

Project Method for Modern School Children:

Curiosity is the main stimulus to intellectual process. It is natural among children, though uncertain in its growth. It is easily aroused but it is difficult to maintain. The interest and curiosity of pupils must be developed without being broken by the compartmental

nature of the curriculum. This is the general principle on which its contents should be selected. Though this may come in the way of the systematic study of a subject it will be of great advantage to give it free scope to play even if it is beyond the jurisdiction of the subject. That naturally involves the concept of the unity of knowledge. One subject must not prohibit the interest and curiosity of children from trespassing into the other. This nature of interest comes in the way of satisfying its natural urge. In science, it is preferable to consider all aspects together than to divide them into compartments in the modern school. This helps a skillful teacher, to cover a wider field of science. Similarly with regard to the remaining arts subjects. They can be together considered to constitute the general arts.

The Project method is really a work both to the teacher and to the pupils alike. Thereby, it is possible to relate the whole body of pupils' work and experience in the study of science or other subjects, to the central core of his interests. Soil, town, transport, tools, sea, etc., when studied as a topic, each can give a unity for a large variety of topics belonging to different branches of science. The pupils to work out the topic, will have to undertake investigations and discoveries in widely differing fields. There is scope for the full play of various kinds of interests and abilities. There should be historical possibilities; there should be geographical possibilities as well as scientific possibilities and scope for technical investigation.²¹ Above all,

there must be the local setting to procure interest of the pupils and arouse their curiosity which will work as the motive force to carry on the project to completion. Excursions to places of necessity will have to be undertaken; facts and figures are to be collected. This helps to develop their reading and arithmetic ability. In actually working the project the pupils will advance in technical skills or writing, calculating, manipulating, constructing, sketching, painting, etc. But the teacher should have a special measure of imagination and alertness. He must act as supervisor instead of instructor. He must carefully coordinate the fields of experience whether of arts or of science in such a way that at the end the knowledge gained and the methods and attitudes developed, become systematic and harmonious.

Some children may require additional stimulus. This may be provided through pictures, films, film-strips, wall panels, flannel-ographs and even teachers' diagrams and notes. This visual programme will help to bring in to the scene, the historical, social and scientific settings to arouse the curiosity of such children to the needful extent. This kind of approach which is most popular in America is familiar to most teachers in United Kingdom. But they do not show enough interest in the technique on the ground that it may not provide adequate intellectual training. This reason also holds good with the traditional approach. But the project technique, if properly handled will as certainly provide the same sort of intellectual training as that provided by the traditional methods. The collection and comparison of facts, the consultation of sources of knowledge, the interpretation of evidences, the bold postulation of hypotheses,

the establishment of principles, formulae, or laws from particular examples, the analysis and synthesis involved, the realisation that the requirements of an investigation demand the mastery of a technique to make further progress - all these are first-rate training. The use of heterogeneous materials will make them understand how all subjects are united and inextricably related to life. Of course, this particular technique may not produce first-rate scholars or specialists. This is not the object of the modern school. But, it gives a very good social training in developing in the individual, the sense of responsibility of his share in the common lot of society as an interrelated individual. Such a project can be arranged exclusively for science programme in the modern schools.

Classification and Programme of Work in a Modern School:

Children in the English secondary schools are often classified on the basis of their attainment in mother tongue and arithmetic. They may be classified into two or more streams arranged on this basis. The abler children are grouped together while the less abler ones form a separate group, so that teaching may be adjusted to their ability. The latter group requires a different approach and a simpler presentation of the matter. The teacher also must be more sympathetic towards them. For this purpose intelligent tests are often used. But classification based on this, often, may prove bad and hence a subsequent testing and sorting will be essential on the basis of their future performance. In this way pupils can be classified according to their ability for instructions in all the fundamental subjects of the school curriculum. It is found by experience, such a grouping will hold good even from the point of view of science abilities. But

segregation should be limited and the school must have ample scope for social contact among the various types of pupils in the school, during the remaining period when classroom instruction as such, is not ~~and~~ provided.

One main defect of such a method of classification on the basis of pupils' achievement in mother tongue and English is that an extraordinarily talented pupil in one or the other subject is likely to be treated as dull if he is weak in mother tongue or arithmetic. So, the best method of classification is to arrange the streams on the basis of their ability in each subject. This can be done in two ways:

1. A form may be sub-divided into groups; all the groups may work under one teacher; the teacher may teach the subject according to their ability. Tasks may be graded and set according to the children's varying capacities in that particular subject. This is specially suitable where the work of the form is organised round a centre of interest as in the project method. This is one of the types of streaming out pupils of a form.
2. The second device is to stream out pupils of a form into different pattern according to their aptitude. They are the subject streams like language streams, science streams and craft streams. Instead of calling language stream sometimes, it may be called Milton or Shakespeare stream. Similarly the Science stream can be called as Newton stream or Faraday stream. The craft stream can be called as Morconi stream or Gilbert stream.

Such a classification gives an atmosphere of culture and inspires them to devote themselves for the cause of humanity. In addition to its cultural colour, the above basis banishes from the minds of the pupils the unpleasant feeling that one is weak in certain subjects. Further, this breaks class tradition and builds democratic attitude. This aspect of the school organisation helps in our attempt, to select and conserve science talents. But, it is essential that all pupils of one stream should be under one master or one mistress.

In view of the fact that there is a demand for lengthening the duration of the modern schools from four to five or six years, it is desirable to provide special courses to them so that they may develop mastery over certain subject or craft or art.

Whatever it may be, the curriculum and time-table in modern school should be varied and flexible to suit the varying ability and aptitude of pupils. This statement applies equally well to science also. A number of modern schools which I visited, exhibited great flexibility in the way in which the curriculum was adapted. Boys and girls who were abler, had the full complement of the contents from all branches of science. Whereas, the weaker ones had a comparatively simplified course of study in science. The lowest stream represented very backward children particularly in their ability to study science and they were neither eager nor able to learn science topics of a serious nature. The school had wonderfully adapted the basic curriculum to their needs and interests. One of those boys studied radio. One of the girls was advised to study telephone. They really showed interest in such types of concrete learning. They had sets of the above apparatus. They could dismantle, reassemble and even learn to repair. That was a course of science that best suited their ability, needs

and interest. What a democratic adjustment! The school programme is being adjusted to the interest, ability and aptitude of children.

statement showing the allocation of time for science in a Modern School:

I Form - 2 periods of 40 minutes each, or one double period of 80 minutes.

II Form - 2 periods of 40 minutes each, or one double period of 80 minutes.

III Form - 2 periods of 40 minutes each, or one double period of 80 minutes.

IV Form - 2 periods of 40 minutes each, or one double period of 80 minutes.

(In all there are 35 double periods per form per year. About 35 topics form the science course).

The above allocation of 80 minutes for science per week in modern schools appeared to me as if the subject was practically neglected. On enquiry I found that for regular class work in any other subject, no special distinction was shown. The time for mere verbal programme was curtailed. Rather, the time saved thereby was devoted for activities and projects in science as in other subjects. Only two periods of forty minutes each were set apart for science. These two periods used to come continuously. So, they could get 35 double periods for science programme per year. Accordingly the science course for each of the form was divided into 35 topics, each topic to be covered in one double period. But the period during which the pupils engaged themselves in activities, directly contributed to enrich the school science programme.

Secondary Technical Schools:

Though secondary technical schools have appeared in a new garb, after the act of 1944, they do owe their existence to a variety of earlier schools that provided semi or fully vocational education in England. It is interesting to note that many of those post-primary schools had

developed themselves in accordance with the industrial demands of the society. Their gradual perfection from stage to stage, until they all became secondary technical schools after 1944, is an interesting chapter in the history of educational experimentations in the English post-primary stage. The following types of schools can be considered as the forerunner of the secondary technical schools:

1. Junior Technical schools of two types:-

- a. The trade schools that trained pupils for particular occupations - They were almost confined to general area.
- b. The schools that trained pupils for the general group of industries connected with engineering with all its branches - Pupils could go for further education.

2. Junior Commercial Schools:

One third of the total time is devoted to subjects that are directly vocational. General education is provided during the 2/3 of the remaining period of school life.

3. Home training schools:

Out of 220 Junior Technical schools only 9 are Home Training Schools. They provided a liberal education with an excellent background of home training.

4. Junior Art Departments:

This is part of the Art School. These are not therefore regarded as junior technical schools where as items 1, 2 and 3 were generally regarded as junior technical schools.

The junior technical schools of various types did exist in England and Wales since 1905. They were in contact with industry and commerce. Their main success was due to this intimate relationship. The difficulty with all the above schools, was that though they gave education from 13 to 16, they did not fit into the frame work of

secondary education and did not hence enjoy the status of grammar schools and modern schools. Though some of them were bad, many of them provided an all-round education and even paved the way for higher education in technology. Those pupils could obtain National Certificate (Higher) by part-time study. At least, ^{such of those} institutions and features which were really good, could be preserved and developed. It is these pioneering institutions that were later converted by the new Act, into the secondary technical schools. Hence the secondary technical schools also like the secondary modern schools, have a tradition behind them, in those junior technical schools.

A Link with Industry and Commerce:

The distinguishing feature of the secondary technical school is in its relationship with a particular industry or occupation or a group of industries and occupations. No doubt, the technical secondary education is not narrowly vocational. In fact, at the age of adolescent youth, the education must be to some extent, vocational since a good general education should prepare for the whole life. Such a general education is concerned with the boy or girl who has to live as an individual, and to live and work with others. Preparation for the work which he or she should do for the community in the form of earning a living, is bound to enter into any kind of education at the secondary stage.

The secondary technical school is different from other schools in its selecting the particular link with the sphere of industry and commerce from adult life. Other secondary schools are closely linked with life in different other spheres. The secondary technical school

caters for a minority of able children who are by aptitude interested in a curriculum coloured with industrial atmosphere and who are attracted by the particular job or profession. Such students usually show interest in science and its applications. There is suitable provision for the full development of their particular talents or special abilities. Further, such subjects like Literature, Art, Music, History, religious instruction and Physical Education are common with the other secondary schools.

Secondary Technical School no doubt, is not the only avenue to responsible posts in industry and commerce. Many boys and girls who respond best to grammar and modern school education may ultimately follow technological careers. Whatever the type of school it may be at the secondary stage, the school should establish appropriate link between school and world outside. The pupils will thereby, recognise the practical significance of the studies at that stage. Such a link is especially valuable to those boys and girls whose dominant interest is in a career. If the school work of pupils is based on such interest, it can gain enormous meaning and purpose.²¹ Such a meaning and purpose will act as the strongest incentive to draw out the best that is in them, thus providing opportunity for the full development of the personality. It is in this sense that the technical secondary schools provide a cultural education, even though they include one or the other vocational subject in their curriculum.

New Needs and Opportunities:

After the act of 1944, though the junior technical schools are still functioning in the same old way, their status is definitely changed leaving before them a wide field of development. From being a part

of the provision for further education, they have become an integral part of the secondary education. This has ensured the inclusion of an extended programme of science and other subjects for general education. Hence, they can in future, develop into equal partners with the grammar and modern schools. This changed position has made the new secondary technical school quite different from their fore-runners.

Instead of two-year or three year course from 13 as in junior technical school, the secondary technical school admits pupils at 11+ and gives a five year education upto 16. Even after that, pupils may stay till 18. Good buildings, ample equipment, spacious school grounds, meals arrangements and many other facilities have also raised its status and standard. Though the name is technical there is no scope for early professionalisation. A preliminary general education with the same standard as in other modern schools, is maintained. Professionalisation may later set in. In science a broad general education in the early part of the course will be later followed by, specialisation of such aspects of science which may apply to the particular vocation. Similarly in other courses of studies. Industry and commerce in the school are not to dominate but to enrich the education of those particular boys and girls, through those aspects by which they have influenced human civilisation.

^{15.}
Science as Core and Inspiration:

Spens Committee Report while suggesting that the curriculum of the technical schools must be same as that of other secondary schools, did suggest that:

"For pupils of 13 and onwards the curriculum should be designed to provide a liberal education with science and its applications as the core and inspiration".²³

Though it has given importance to science, other subjects are also taught as in other secondary schools. Among the subjects taught are English, History, Geography, Mathematics, Science, Engineering, Drawing, Practical Crafts in the workshops, Physical Education, aesthetic subjects and continuation of foreign language (only for those who will be capable of profiting by it).

Though there is lot of application in the science curriculum of the technical school in the matter of subject titles, there is a close approximation with similar aspects of grammar school science. It is in the method and approach that real difference should exist. Such difference no doubt, is difficult to describe by words. A detailed teaching syllabus can bring out that difference. Certain aspect of science will find application to particular trade or job or manufacture. The teacher naturally should give to those topics of science, a different emphasis and a different treatment. He can manipulate the syllabus in any way he pleases, to make pupils understand how a principle that operates in nature can also operate in the working of certain machines. His application, adaptation, emphasis and treatment need not be hampered by an external examination. The following time allocation for various subjects is usually made in a technical secondary school:²⁴

Out of $27\frac{1}{2}$ teaching hours

English subjects	...	6 hours
Mathematics & Science	...	8 hours
Workshop practice	...	$4\frac{1}{2}$ hours
Engineering drawing including practical	...	3 hours
Physical training Aesthetic subjects	...	3 hours
Pool	...	<u>3 hours</u>
		<u>27½ hours</u>

The above statement clearly demonstrates the importance that is given to science in a technical secondary school. This allocation of time was suggested by the Spens Committee, in 1938. At present in actual practice, this is followed to a great extent. Allocation of time for science in one of the technical schools which I visited, was as follows:-

statement showing the allocation of time for Science in the secondary Technical School at Bristol:

I Form	I
	* General Science - 2 periods of 40 minutes each.
II Form	I
III Form	Physics, Chemistry and Mechanics - 8 periods of 40 minutes each.
IV Form	Physics, Chemistry and Mechanics - 2 single periods and 3 double periods or 8 periods in all.

It should be borne in mind that no secondary school aims at teaching any particular trade operation or even several operations merely in order that a particular boy or girl can go straight, from school and perform them continuously. No doubt, many of the skills to which pupils are introduced, will be of great practical value, but the skill in themselves are the main objects of the school. Though secondary technical course is generally with an industrial group, the education it offers must be fairly broadly conceived to stimulate and benefit pupils who may not pursue a career within that particular group. The selected industry in addition to being locally followed, must also have a broad enough basis with scientific and factual content which can be used as a part of a school course.

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It is in this way that the vocations of a secondary technical school also give a liberal education. The old technical schools were mainly linked with engineering, building or commercial arts. Agriculture and mining also offer obvious opportunities. Similarly, there are other branches of industries as well as commerce, home training and the arts which also should be encouraged.

Science Curriculum in the Secondary Technical School:

The science curriculum of the secondary technical school varies from school to school in accordance with the nature of the technical subject. Every school with the same group or groups of industries, may have widely differing types of curriculum. We may consider here not those varieties but some common aspects of the secondary technical school science curriculum.

In fact the curriculum of the junior technical school is maintained and improved and broadened to ensure better standard while maintaining and covering the old field.

The science curriculum is so planned that the industrial interest will not dominate but gives a coherence and stabilises the course. In modern schools to secure such a coherence and stability, the project technique is used to organise the science curriculum. In the secondary technical school the industry is the project which holds all elements of the curriculum together, but doing so, without distorting them. Thus the curriculum in science relates to the particular trade on the one hand and ensures the coherence of scientific culture on the other.

During the first two years, the secondary technical school should have the same general science as in other secondary schools,

continuing the work of primary school and extending and strengthening those achievements in concept, skill, qualities and application useful for all walks of life. It should include sound practice in the use of instruments and tools with a sense of precision and accuracy. Further, appreciation of quality in material and workmanship should be provided. Some simple knowledge of other people in other places and other times will also be included. An appreciation of the historical fact as to how they adjusted and controlled their surroundings, will also form an essential feature of the science curriculum.

The curriculum in the third year will consist of mainly an introduction to commercial, industrial and other applications of basic principles of science, in a gradually increasing emphasis on particular aspects of certain subjects instead of introducing entirely new subjects like mechanics, etc. The teaching of science, significant only in relation to some particular industry or commercial operation, is certainly not justified. All the topics^{of the} course mentioned in the previous para, will be carried further in the third year. It is frequently seen that the technical schools from the third year, drop off biology and include mechanics, physics and chemistry.

In IV and V year (14 to 16) the bias in the science curriculum can be more progressively increased; the work of the school may be more deliberately related to the main centre of interest. Even then this bias may be more in the kind of approach than in the kind of subject matter except in matters where technical theory and practice are involved. Attention will be paid to retain the essentials of the broad general education programme through science though in the last year it reaches the stage, when one may call it applied science.

The claims of a secondary technical school for giving a sound general education through science must be gauged not merely by the standard they achieve in particular directions or trade but also by the measure of their success in sustaining the interest of pupils in all aspects of science as a subject of general education.

New Principles to revolutionise Science Curriculum at the Secondary Stage:

Any sound principles of curriculum making should be based on psychological and sociological needs. Naturally, such principles should evolve a really useful type of science curriculum. Such a curriculum should -

1. Cater for the special needs of adolescence. It should be related to the body and mind of the pupils and illuminate and guide ~~their~~ experience.
2. It should not enlist topics only for their utility when pupils go to higher studies.
3. It should be an all round experience of the material universe giving full opportunity for the pursuit of individual interests and abilities.
4. It should stimulate or create the desire to continue some form of study after leaving school whether they join the college or higher studies or leave the school once and for all and follow some trade in life. ²⁶

If the courses of studies in science satisfy the above conditions it may undergo any modification in the hands of a skillful teacher. But, at every stage, his freedom for altering the topic or the method

of approach, should be governed by the fact that he has to produce a generation of men and women who are sensitive to beauty and truth, ready to think and observe carefully, exercise caution in accepting evidences and drawing conclusions and above all, prepared to analyse the mysteries of nature and apply their experience so gained, to improve the affairs of mankind.

The educative value of any science course consists in its suitability and usefulness in providing material for thought, for the perception of relations and for the matter on which the pupil can strengthen his power of reasoning. The value also consists in its invitation to the pupil to form interests of sentiments about a subject. It is also true that the value of a subject lies in its building up of such habits as perseverance, sanity of judgment and initiative and in the building up of a group or complexity of habits which constitute a skill. No doubt, these values are inherent not in a particular subject but in a particular method of studying any subject. But, the choice of subject is equally important and any subject selected must be worthy of study. It must represent a line of activity, intellectual, aesthetic, or practical, which has played an essential part in the evolution of ^{the} human spirit. Above all, it must be related to human life now, and should be one that is likely to be related in future. Indeed science as a subject is pregnant with all these special qualities. It develops all those mental abilities which go to shape a sound and healthy mental life for a modern society. Its method of study has its intrinsic values for disciplining human observation, accuracy, precision, organisation of facts, recording and reasoning. Above all, there is that superb provision in the

method and its study to hold a number of isolated facts in the nutshell of a principle, a law or a formula.

The nature of the study of science as a conscious effort of analysing the mysteries of nature, provides a first rank intellectual training for the pupils. The applied part of the subject is an evidence of its intimacy with human life. Historically speaking, like any other subject of study, it represents the grand expression of human spirit. Added to these, in these days of industrial civilisation it is the singular subject that provides that unique technological and technical ability for the individual to maintain himself and to play his legitimate role in the modern economy of the state. Naturally, such a subject should rightly claim a place in the school curriculum at whatever level of instruction it may be, as a subject of general or liberal education.

The English secondary schools enjoy great amount of freedom. There is no such a thing as central control. Hence each school is free to evolve its courses of studies in science or in any subject, in its own way. No doubt, there is an external examination at the end of the course, but the number of pupils who take up the examination is too small. Generally, Grammar schools send up students at the end of five years, to the 'General Certificate in Education' examination. There is another examination after two more years. This is the Advanced Level Examination. They can also take up the Scholarship Examination at the end of the secondary school. Though a small percentage of modern school students do take up this examination, the majority of them do not take up any examinations at the end of the course. The students in the secondary technical school usually, take up the school technical examination at the end of five years or at

the age of 16. This is an internal examination with certain amount of external assessment. They may also take up the G.C.E. examination at all levels. This examination is generally conducted by the University Boards. In addition to these University Examining Boards, there are other Boards of Examination such as "The Associated Examining Board", "City and Guild Examination", etc. Universities and other ~~set~~ Boards set their own syllabus for all the subjects, examine and set their own standards for admission. One may expect that the presence of an examination of this sort, at the end of the course will bring about some uniformity in the courses of studies. Though this is true to some extent, there is a good lot of diversity from school to school. This is mainly due to the following factors:

1. Freedom from central control;
2. The variation in the standards set by various examining bodies;
3. The adaptation of the basic syllabus to the needs and abilities of the children on the one hand and to the particular trade on the other;

With regard to the other secondary schools, this variation is still marked. This is mainly due to the absence of an external examination at the end of the course. It is also due to some extent, to the effort on the part of the school, to prescribe its own syllabus in accordance with the needs of the children, their abilities, age and interests. The modern and technical schools enjoy greater freedom in this respect. Hence it may be stated that the special features of the English secondary school science syllabus is in its great variety and diversity. One can reasonably expect that the progress of school science programme will be greatly facilitated by the experimentations that are taking place in the secondary technical and secondary modern schools. It is in the field of these two types of schools that one can expect, the evolution of some desirable features of the secondary education.

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CHAPTER VIII.

Science Programme in Primary Schools.

The acceptance of the responsibility of providing primary education by the State has helped not merely to improve and widen the scope of primary education but also to include some of the new elements into the school curriculum. One of the most important developments in the field of primary education, during the early part of the first quarter of this century, was the provision for teaching of Nature Study for children. Nature study both as a course and as a technique of teaching, was derived from the object lesson of the earlier generation. Object lesson both as a course of study and as a ^{method of} teaching, was rather, discarded in the first decade of this century to give place for Nature study, as its course was cut to approach science more nearly. The subject included the study of common phenomena, common animals and common plants. The general objectives of that course were -

1. To improve children's power of observation;
2. To create an interest in nature, and
3. To develop the power of expression.

A review of the objectives of Nature study indicates that it has to widen its objectives and subsequently its contents, to make it a science course fit for children of the scientific age. The present children are not in the same position as the children of last century. They are today, moving in a society on which the ever-increasing impact of science has produced marvelous changes. The children are affected by these changes and naturally they have both a right and a responsibility to know what are those things that are newly introduced and

how they have revolutioned^{is} human life. Further, they also have a right to know in what way their own lives are controlled by those changes and new events. Evidently, they must know, in addition to what is interesting in Nature, those things that are the results of human endeavour. It is human achievement that has been responsible for placing the present day children in a civilisation that was not even dreamt of by the earlier generations. The child of today is certainly surrounded by a host of scientific inventions. His life is continuously being influenced by the contributions of science. His interest is greatly activated by the wonders of science, that attract his attention. Such being the case, science does influence the life of the children as much as it does the life of adults. Naturally, it becomes evident that they will have enough curiosity about a good number of scientific achievements. It is but proper that the adult society should provide opportunity for the child to know about these things.

The primary schools have included in their curriculum, subjects like language, arithmetic, social studies etc. Science should have as much consideration for being included in the primary school curriculum as any other subject ~~and~~ of study.

Special aim of Science teaching at this level:

No doubt, the broad aim of teaching science at the primary school level is practically the same as that of teaching it in the secondary school. But, for every stage of the child's life, education has a particular objective in addition to those broadly accepted general objectives. The interests of the child differ at the

different stages of its life. Those interests must be developed. Keeping this in view, the special aims of science teaching at the primary school level as held popularly in America, and as expressed in a bulletin by the Bureau of Education of the Federal Security Agency, are indicated below:¹

1. To provide experiences as a means of forming science principles and generalisations;
2. To help ^{them to apply} those principles and generalisations to interpret things that happen around them;
3. To give practice in the use of scientific attitudes and skills in problem-solving and
4. To broaden their interest in the everyday phenomena of their environment.

Croxton in his bulletin on the objectives of Elementary Education, states that the general aim of science teaching should also be realised at the elementary level.²

The fortysixth Year Book of the National Society for the Study of Education (N.S.S.E) has given an elaborate list of the functional objectives of science teaching at the primary school. They are summarised below:³

- A. Functional information about our universe, living things and human body;
- B. Functional concepts such as the vastness of the Earth, the age of the Earth, the evolution of life from simpler forms and the electrical nature of all matter;
- C. Functional understanding of principles such as reproduction in animals and change of form of energy;

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- D. Instrumental skills such as ability to read and understand with satisfaction and to perform simple manipulatory activities with scientific equipment;
- E. Problem solving skills such as the ability to identify a problem, make the best tentative explanation or hypothesis and to test the hypothesis by experimental and other means;
- F. Attitudes such as open-mindedness and willingness to consider new ~~things~~ facts, intellectual honesty and scientific integrity;
- G. Appreciations such as the contributions of scientists, the basic cause and effect relationships;
- H. Interests in scientific recreations and hobbies and in the scientific vocations.

The above list certainly, applies equally to the teaching of science at any other level. One may feel that it is too ambitious for an elementary child, but it should be remembered that those objectives are to be particularly realised in each of the stages of growth to the extent of its intellectual maturity, emotional development and manipulatory ability. Hence it clearly means that the general objectives, should be developed at every stage but on expanding and extending as the child goes from grade to grade. With regard to some of the concepts and principles, true, it is not much for the elementary child to master. But we must remember that the rigour of method should form the end-point of science and not its entrance gate. Further, the concepts and principles should be studied by the child not in their formal nature but in their functional aspect. Thus, it becomes clear that even though high sounding words and far-reaching aims are used in the objectives, they are merely the end-points and not the entrance-gate. It also implies that the child should achieve in every one of those fields.

objectives, in harmony with its mental, emotional and motor development.

The above list of objectives of science teaching for American Elementary schools ^{may} seem to be very ambitious to an English Science teacher. He would prefer to make a more workable and less ambitious statement of aim. The wonder and romance of science with their strong appeal to the natural interest of the children, will create in them a natural desire to know things around them.⁴ It will help the children to observe carefully and dispassionately, to formulate one's observations in words or other ways and to make proper inferences from what has been observed. As expressed by the Board of Education, the child after all, ^{neither} ~~cannot~~ progress in the abstract regions of scientific thought nor can it achieve anything in the more technical applications of scientific method.⁵ But the primary school child certainly, can follow what is involved in careful investigation and systematic relation of facts to principles and principles to facts, if he is acquainted with some examples of great pioneers of science who have attacked and solved problems. No doubt the child is not going to be trained as a scientist for matured investigation; he is to be trained to investigate his own problems in the world that surrounds him. It is essential on the one hand, to satisfy his natural urge and to provide a scope for the expression and development of his interest ~~on the one~~ ^{of} ~~hand~~ and to assist him in the unfolding ^{of} his ~~own~~ personality, ^{on the other,} ~~on the~~ ~~other.~~ Though he is unable to understand the formal aspect ~~concepts~~ of scientific concepts, principles and formulae, he certainly can be made to realise the role, science is playing in the modern life. He can also learn how to deal with some of the every day problems or applications and develop some healthy and desirable habits. The

English teacher who is keenly common-sense minded and attends to practical possibilities in his theoretical treatment, wants to achieve the above objects by the teaching of the old Nature study, while the American science teacher would rather, stress on human achievement. But, both believe in the fact that the aim of teaching science at this level must be, to make pupils' experience in the school life more significant and richer. Therefore, it becomes clear that the present trend is to provide experience through various activities which will help the children to adjust to the surrounding environment physically, naturally, emotionally and intellectually. As the adjustment process is proceeding, the children will be enabled not merely for adjusting with the environment but also to control it!

Hence, it becomes clear that the aim of teaching science in the primary school should develop out of the activities they experience in daily-life. This experience and the subsequent activities will enlarge as the interests of children grow. Naturally we have to provide adequate activities to quicken and keep alive the spirit of wonder and inquiry. This is to be done through the provision for observing plants and animals to gain first hand information on the one hand, and for observing the wonders of human achievement, ^{on the other.} The work of observation should be followed by suitable activities through which they can develop their expressional art and the practical ways of meeting with situations and manipulating them as per their desire. A special taste of the teacher at this stage, will be to satisfy the growing desire on the part of the children to construct. This can be met by giving practical work to do in connection with their first

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hand observation of plants, animals, natural phenomena and a huge number of things at work, where human achievement is expressed. These activities will lead children to exploration and to interpretation. In fact the normal activities of children are to explore and to interpret. When we think of teaching science through such normal activities and normal ways of living we are right, because their normal dynamic drives and potentialities are used most profitably on the one hand and nurtured on the other.

The contents for elementary science:

The nature of the contents for any grade of instruction in any subject, depends largely on the aim of teaching that subject to the pupils of that particular age group. The aim of teaching science for primary school children is differently ^{or} conceived in different countries. In America, it is widely believed that the ultimate goal of teaching science should be the development of scientific method, ^{scientific} out look, ^{ability and skill in solving problems} attitude and informations in the minds of the pupils. In England, it is believed that the teaching of science should recognise the natural curiosity of children in the things and happenings of the environment and try to establish the need for satisfying ~~the~~ the child's curiosity as the primary aim. Though these two types of aims look different from one another, they are practically the two poles of the same objective. In this connection, we have to take into consideration the potential role that the subject of science plays in the society. So, a comprehensive aim of teaching science should take into account the verdict of the above three factors. As stated in the earlier chapters, India is fast progressing towards an industrial civilisation

based on the application of science to the art of production. Our children will have to live in and contribute for the progress of such a society. For that purpose the individuals should possess certain habits, attitudes and outlooks. They should also equip themselves with certain informations, appreciations and skills. Such an accomplishment can be termed a scientific culture. The personal traits that go to form that culture are believed to be the following:-

1. Critical mindedness;
2. Ability to distinguish between facts and fiction;
3. Ability to seek reliable informations;
4. Scientific planning and execution with meaning;
5. Acquisition of scientific information;
6. Ability to make use of the knowledge of science in every day life;
7. Understanding how science helps us in our individual and social life and
8. A realistic appreciation of the role of science in human affairs.

If the above list were to shape the particular aim of science teaching in Indian primary schools, to enable them to fit into a society of the future, we must not neglect the present curiosity of the pupils about the things and happenings around them. Our aim therefore, should be primarily to enable the children to live a richer life at present and to prepare themselves for the dynamic changing civilisation of the future. Naturally, the contents of the primary school science course should include those activities that satisfy their curiosity about things and happenings in the environment on the one hand, and to provide opportunity to prepare themselves to participate in the



society of a dynamic nature, on the other. No doubt, the world in which they live is full of things and happenings that stimulate their curiosity. They may be natural or the result of human endeavour. The children must have opportunity to engage themselves in activities for which they are prompted by the urging interests. This will also assure them the first hand experience about many things and happenings. It will also enrich their mind with the raw materials that go to form the contents of science. The curriculum should make provision for the children to solve the challenging problems by their own effort. This will ensure the development of desirable social attitudes and behaviour.

Need for integrating different types of experiences:

The makers of curriculum for primary school children, will have to bear in mind that the curriculum should provide activities in such a way as to ensure continuity of experiences, and ^{scope} to learn ~~about~~ some aspects of the active environment. The children must be made to realise that ~~what~~ ^{if} all is taught as science, belongs to one subject, the essential bond or unity being in the similarity of the technique underlying whatever experience it may be; then only will it be possible to develop from the early age in the mind of the pupils, the following aspects that go to form the spirit of the subject:

1. That science embraces the objective study of the entire material universe;
2. That science is exhibited in the natural operations as one subject;
3. That it is conceived by our mind as one subject;
4. That it influences human society as one subject, and
5. That all topics that are studied are interrelated as each one of them has helped the progress of the other in the course of its development.

Such a course of integrated science curriculum draws experiences from all branches of science and organises them in such a way that they are all reunited around the children's immediate needs and interests to provide a wholesome and integrated experience. Whether it is the solution of a felt problem or an attempt on the part of the child to satisfy the urge of some curiosity or an eagerness to explain or interpret a thing or a happening within the orbit of its environment, a variety of experiences will have to be provided. The curriculum must be so limited and so integrated, as to permit the utilisation of materials or experiences from any branch of science. It is on such a broad, wholesome and integrated and general foundation that the science education of children should be started.

Selection and organisation of materials of Instruction:

The community is a big reservoir of resources from which the teacher can draw a good lot of materials for his instructional work. A knowledge of the various community resources and an identification of himself with those resources will enable him to make his instruction more meaningful and functional. Whatever may be the principle on which the curriculum is organised, a knowledge of the nature of the community and its resources will help him to rearrange the same into a working syllabus. While doing so, it is a simple thing to organise the contents of the syllabus round about those resources. Keeping the above principles ^{in mind,} we may try to evolve a sample selection and organisation of the instructional materials for the sources of experiences to primary school children, in elementary science: ⁶

1. The Soil-factors that make soil-soil and man's wealth-soil erosion and effect on community life-soil, the basic needs for life-grassland and human interest.
2. The Forest - its benefits to mankind - Forest erosion and need for conservation - Forest and animal life.
3. Water as a natural resource - Its importance to man, animals and plants. How to get it - water and health-pollution of water a social sin-storage for supply - Rivers and Seas - Rain and clouds.
4. Industry as a human resource: Local industries - Raw materials-energy used - what benefits have they brought? - what is their effect on living standard. The welfare of the workers.

Similarly, a good number of resources both natural and human, can be selected to organise the experience. From the foregoing, it is evident that the curriculum when so organised, looks more homely and functional than formal and academic.

Another way of organising the experiences is to relate them to children's natural interests. There, the centres of interests may take the following form:-⁷

1. Food we eat;
2. Water we drink;
3. Air we breathe;
4. Our shelter;
5. The pets we keep;
6. The plants we grow;
7. The machines we use;
8. The heavens around us. etc., etc.

Facility for Experimentation:

However we may organise the curriculum, we must remember that science should be taught through first hand experiences. Though a good lot of experience is available to children in the various community resources, it is essential to provide some sort of experience within the campus of the school. It means that the curriculum should provide for children's own experiments for getting education through their own first hand experience. Naturally, it leads us to the problem of organising laboratories for primary schools!

The teachers and educators who are interested in the extension and promotion of science education to elementary schools will usually get disappointed when they face the problem of equipping a laboratory for every school. No doubt, they are right in one way. There are millions of primary schools in India. If even the minimum maintenance or laboratory grant is to be sanctioned, the total educational budget will swell by crores. Further, the initial lumpsum amount to be invested over the organisation of the primary school laboratories will be so high that every politician will do his best to banish science education from primary stage and rather think of teaching some humanities like Ramayana, Bharatha, Shivapurana etc. Our leaders must realise that the economic strength of a country and subsequently, their leadership in the world politics, are fundamentally dependant upon the type of laboratory equipment that is provided in schools and colleges. Hence the nation should consider that it is as important, if not more, to provide good laboratory facilities to schools as they do with other constructive programmes for the welfare

of the people. The amount spent over that item, will be doubly repaid in various forms. We are spending huge amounts over temples, mosques, monuments and memorials. Spending the public funds over school laboratories will be better justified and better rewarded. It is with this view of realism that we have to face any problem connected with the welfare of the nation.

Every country whether democratic or totalitarian, is trying to extend primary education to every child of the state. This expansion is intimately connected with the extension of educational provisions in the form of building facilities, equipment, staff and various services to ensure the physical wellbeing of the children. Meanwhile, the modern tendency in education is to blend the good features of the earlier three periods in the history of education. The psychological, the scientific and the sociological tendencies have contributed to shape the teaching method, the curriculum and the relation between education and life respectively. Of the above three periods the scientific age emphasised that the knowledge worth having is science, whereas the sociological conception of education, keeping in view the greatest happiness of the greatest number, stressed the need for providing for scientific and technical education. The realisation of the ideas of the scientific concept of education in the practical field was much delayed. At least, now, the whole world has realised that inclusion of general science in primary stage is as important as compulsory education. Those educationists and leaders who are not prepared to spend public funds for mass education, certainly, will not even think of equipping primary school laboratory.

No doubt, [^]
~~Because~~ equipping primary school science laboratory will be a single big item in the nation's budget, because of the huge number of schools we have to provide for.

This shall in no way discourage our determination to introduce science in the existing primary schools. There is no need to equip our primary school science laboratories in the same elaborate way as we do for secondary schools. The major part of equipment used in teaching science at the primary school, ought to come from the child's own environment. Most of the experiments suggested in the curriculum, can be performed with apparatus and equipment obtained from the home, the school-room or the local stores. There are however, a few experiments for which equipments may not be so easily obtained. Certain amount of laboratory grant is to be sanctioned by the state to each primary school. No doubt, this sanction will be a huge increase in our educational budget. Yet we have to incur. When a country is prepared to spend so much during war time, why not we increase our expenditure, particularly in peace time, for this constructive and positively nationbuilding activity?

Technique of Teaching:

The teaching technique is largely determined by the psychology on the one hand and the objective of teaching that particular topic, on the other. Psychology basing its verdict on the pupils' age, interest, ability and aptitude, may indicate a number of attractive techniques for an effective instructional procedure. But, the teacher will have to select that technique out of the many, which will be



useful to him to reach the desired goals in the shortest possible time, and at the same ^{time,} assuring the best of instructional outcome. Hence, the teacher cannot simply follow the method dictated by psychology. The teacher will have ^{to} use his discretion while selecting a technique for teaching certain topic of certain subject for a certain class of pupils. The broad indications that are furnished by psychology to shape our teaching technique, are to be considered as the scientific aspect of education. The teachers' discretion in making use of these broad hints of the technique towards the effective realisation of the desired goal, is the work of adaptation on ~~this~~ ^{his} part, of the teacher. This forms the artistic aspect of education. Hence, it becomes clear that every good technique of teaching must be based on the sound principles of psychology. The reliability of a technique depends largely upon the extent to which it is based on one or the other laws of learning. This reliability is further, to be affirmed by its flexibility for adaptation to teach the particular aspect of the subject. Above all, in the modern educational institutions time being an important item to pay attention, the ^{method} ~~subject~~ must be economic in bringing about the desired effect. No doubt, there are a number of techniques for teaching science as indicated in the earlier chapters. Every one of them has been evolved with due regard to the principles of psychology and the laws of learning. Yet, none of them can be blindly used for teaching all aspects for all grades of institutions. Every technique has some merit that makes it fit to be used for teaching certain topics of the subject for certain age group of pupils. But that particular technique may ^{also be} ~~be~~ ^{used} ~~admitted~~ to teach other aspects, for other grades, ^{though not with the same effectiveness.} That is why the science teachers frequently express

the idea that no single method can claim an absolute superiority over the other for teaching science. Each method has certain merits and is suited to be employed at certain stage of instruction for teaching certain topics of the subject. The teacher will have to assess each of those techniques in terms of its being flexible in his hands. The most flexible and reliable technique has the best of application in the teaching field.

While considering the suitability of teaching techniques, we have to remember two important facts, namely, that the technique should contribute for satisfying the felt ^{needs} ~~minds~~ of the pupils on the one hand and to develop their personality, both individual and social, on the other. Keeping these factors in view we have to select suitable techniques for teaching science for the primary school children.

Children when they come to the school, ~~will~~ will be subjected to the exciting influences of a number of things and happenings in their surroundings. Naturally, they will be curious to know a good number of things. This curiosity is due to the ~~nature~~ interests of the children and as such possess ^{ex} plenty of energy to secure adequate motivation for learning. The teacher will have to make use of their natural interests and the underlying energy for instructional purpose. The first thing that occurs in the mind of the children ~~will~~ will be the question "what is it?". After observation the child will be able to know some thing about it. This prompts the child and sets up another question "How is it so?". This ^{is} ~~requires~~ certain careful effort to solve. If once this aspect is solved, the child will be able to solve a number of related but distant problems. This acquaintance guides

the pupils to enter a new but broader and abstract world of curiosity. He faces the question "why is it so?". The realisation of the answer for the last question requires the use of their previous experience, ~~gained while answering the second question.~~ If the earlier questions were to supply facts the third question will develop concepts in the minds of the children.

Facts and concepts are the two important aspects of the subject of science. If we were to teach science we may feel satisfied with the realisation of those outcomes. But we have to teach the child. The facts and concepts are not the end in themselves but only means to an end, the end being the development of the whole personality of the child. Our teaching of science should result in the development of certain desirable attitudes and outlooks on the part of the child; the facts and concepts taught, should go to develop in the mind of the pupil, an intellectual understanding and interpretation of the material universe; they should also stimulate in the child the development of certain desirable habits and behaviours; above all, the instruction should result in the improvement of the life of the pupil. In addition, the teaching of science should provide an insight into the problem of the conscious control of nature in the interest of mankind. If these objectives are to be realised the facts and concepts should not go to be stored merely in the mind but should participate in the development of the personality of the child. Naturally the child in addition to the above question, will cherish a fourth question, namely, "what does it say to me?" Hence any technique suited for teaching science for the primary school children, should take into account the above four questions that the child naturally faces in order of sequence.

The above questions and the order of their arising have been observed even by the teachers of the ancient world. The realisation of the above fact prompted Pestalozzi to invent his object lesson technique. But, his technique when applied to the teaching of different subjects like geography, natural history etc., degenerated into an ineffective routine method. But it gave place to another technique namely the Nature Study technique in the closing decades of the last century. Here a definite effort was made to evolve a technique suited to teach science. This technique was based on the pupils' interest in nature. Observation of things and happenings in nature followed by the scope for the expressional art as followup work, was the essence of the Nature Study technique. This technique was probably adequate for the teaching of Nature study. Today, Nature study is decidedly inadequate and it is gradually giving place for a functional general science course. This necessitated the improvisation of the old observation technique. In the new technique observation does appear as a distinct step. But it is subjected to control and thus becomes experimentation in general science. The child manipulates and studies the thing or the happening or the situation and thus gets acquainted with those phenomena, not merely as they are, but also as they were and as they will be. This also helps the child to observe and record facts. These facts are not end in themselves as in the case of the old observation technique, but they are merely means for further prospects. The child reflects over those facts and their relation until it can come to some sort of generalisation. Thus the child proceeds from facts to concepts and principles. A further step becomes inevitable. The child wants to realise how those concepts are affecting

or likely to affect its own life. Hence such a technique practically ^{ch}approaches the inductive-deductive way of teaching. The main steps being:

1. The situation (problem);
2. The exploration (experimenting & observing);
3. Generalisation, and
4. Application.

The above steps of the new method approach roughly to the steps of the scientific methodology which is the method of discovery. To the child every aspect of this universe, of this nature, of this society, of its family and or itself, is a wonder. This wonder is to be investigated into. For that purpose the best suited technique is one which follows the steps of the method of discovery or invention. No doubt, it should also be flexible. That is nothing but scientific technique or the inductive-deductive method.

From the foregoing it becomes clear that any method for the teaching of science, should be on the inductive lines with a scope for deductive approach. To retain some of the good principles of the observation technique, ~~we may that the new technique~~ should provide for a follow-up work in the form of describing, drawing or modelling. This adds to the effectiveness of the technique as it ensures the development of expressional art in the child.

Problem Solving Facility:

Ability to solve a problem that may face the individual, is one of the desirable ~~g~~outcomes of science teaching. Any method of

teaching science should take this into account and make adequate provision within the teaching technique, for bringing situations which will train the pupil in this particular ability and skill. No doubt, man is facing problems and trying to solve them from the very early days. But it was not considered by early thinkers that it shall be an outcome of education. A suitable technique of training the pupils in facing, tackling and solving the problem was not evolved. This is a new ^{feature} ~~feature~~ in the educational practice, and in this particular aspect ^{it} has been reorganised only in the modern days. Evidently, this is because of the fact that ~~the~~ the modern society is one of countless complexities. One has to face problems at every step and the ability to face ^{and solve these} problems ~~as well as those of tackling and solving them~~ should be considered as an essential requisite in every individual.

Science as a school subject, is ^{present} ~~pre~~ prominently suited to train the children in the aforesaid abilities and skill. Though the training given in this field will not be transferable to any other field in life ordinarily, the method of solving when taught to the children, will ensure some amount of that transfer.

The ordinary method of telling may, to some extent, impart some facts and concepts. The method has to realise other goals like functional efficiency, desirable attitudes and appreciations, social sensitiveness and ability and skill in problem solving. The subject matter is no doubt, a means in realising the above goals.

While teaching the subject matter the method should be so adjusted as to provide scope for thinking. This activity of the pupils is the basis for developing the ability and skill in problem

solving. Every science teacher should know the steps of scientific thinking. The first step is the facing of a perplexing situation. This is something like a cross-road situation. The pupil will have to think before moving in one road or the other. He has to think before taking a decision. He has to define the problem. This is the second step. Then, he has to collect the data relevant to the problem. This is the third step. In the fourth step he will set the hypothesis and test the same in the last step. In an inductive process there is scope for all these steps except the last. To make the thought process complete, the last step namely, testing, verification or application stage will also be essential. ^{The addition of such a step} ~~Such a step becomes~~ ^{make it} an inductive-deductive technique. A more elaborate procedure of the scientific or the problem solving technique is given below:-

- a. Facing a problem;
- b. Delimiting the problem;
- c. Devising an experiment;
- d. Collecting and organising the data;
- e. ^{ing}Propos^{ing} an explanation or ^{ism of}formulat^{ism of}a hypothesis;
- f. Testing the hypothesis or explanation;
- g. Discovering the basic truth and
- h. Application of the principle or concept to specific cases.

While teaching science particularly for children, this problem solving technique which is inductive in approach, is really the easiest method for them to learn. At the same time, they are placed in a problematic situation and try to find out for themselves. While doing so they may or may not pass through all the above steps. But, they

have to proceed in the same order. If not, they will jump into false conclusions or arrive at baseless interpretations or wrong explanations. The teacher while teaching the topic of science has to guide the pupils to think and reason out on the above lines so that they may get into the habit of problem solving. The inductive approach to the topic has plenty of potentialities to develop in the children particularly, their ability and skill of problem solving. That is why the particular line or procedure is recommended as a suitable technique for teaching science in the primary schools. No doubt, the ~~in~~ inductive technique is time consuming. The pupils will have to start from the raw data to understand the truth or to solve the problem. If the ready-made solution is given by the teacher or told from the textbook a good lot of time may be saved. By that technique the pupils may however, solve their problems. The teacher may be able to impart the facts and principles. But the more desirable outcomes of science are lost. Moreover, no school need worry about any public examination at that stage and hence it is worthwhile spending some more time over the same topic. The children really like that way of learning. Because, it provides them with plenty of creative experiences and keeps them active. They will show great interest, because of the strong purpose behind it. They learn the truth as the early discoverer did, and feel that they have also done a piece of new work or research. The setting up of such an effect at the end of the learning, is ^a sound principle of teaching method.

Use of teaching aids:

Science is a subject that is to be taught with the help of

materials or situations that can be perceived by our sense organs. They are the basic things to start with. The teacher will have to use apparatus and appliances to experiment, demonstrate specimens, write diagrams and display various types of pictures and graphs. These are intended to make the pupils understand better. But some times it looks as if these aids themselves are important. It should be remembered that after all, they are mere aids and should not become more important than the topic. Excessive use of visual aids are said to produce harmful effects in the long run. They come in the way of developing the thinking ability of children. Instead of teaching ~~science as~~ concepts, and principles and even facts ^{of science} as abstract things, aids of various types may be employed to make the lesson more concrete.

In our primary schools the teacher will have to use his own aids to a great extent. The advantages of such home-made apparatus are evident. They can be easily prepared at a low cost. The pupils show greater interest in learning because of the familiarity of the apparatus. They ~~also~~ ^{also} may try to prepare similar things and thus improve their mechanical skill and ^{develop} a respect for manual labour. It gives scope for the improvement of their expressional ability too.

Other visual aids like the specimens preserved, ~~or~~ dried, or stuffed, can be collected and used as aids. The teacher can prepare his own models and use them in the place of actual specimens. Ordinary models may be of great use to teach topics connected with biological science. Working models are better to teach topics of physics and astronomy. Charts and diagrams will also be of great value; while

teaching topics involving comparable quantities or qualities, pictorial graphs may be of particular use.

Children of the primary school do show interest in studying topics in social setting. Films ^{and} film-strips either connected directly with the topics or connected indirectly with the topics can be used as aids to teach. But it will be very difficult for the rural children to have this opportunity. Films and film projectors can not be purchased by all schools. Even to supply them from central or state store will be very difficult. But it is possible to fix up a day for each school in a week and provide apparatus. This arrangement is possible if a 'central scheme' for each group of villages is organised. Even that may not be possible in the near future, because of the huge financial implications. The national extension services can however help the schools in their jurisdiction, to some extent.

Some of the biological specimens can be demonstrated better under microscope. Pupils will really enjoy to see ^{an amoeba or} ~~amoeba~~ a *uglena* moving or dividing. They will have opportunity for observing about microanimals and plants about which they hear so much. Even the structural details may also be demonstrated on a larger scale which helps learning. But, it is very difficult to provide a microscope to all primary schools. Even in England a good number of junior schools do not possess this equipment. However, our primary schools can be provided with magnifying lenses, field lenses or Tripple lenses. The teacher can make use of them to demonstrate some minute specimens or structures on an enlarged scale.

The Bulletin Board:

The children can be trained to collect science news that appears in the news papers, magazines and other periodicals. They may be encouraged to collect informations from scientific papers and magazines and to write it in the form of a science 'news letter' and post it on the notice board for the benefit of others. The children may be entrusted with this work in turn. This will help them in three ways:-

1. They develop an interest in the progress of science.
2. They come to know how science is related to life and
3. They develop their expressional ability.

This can be insisted in every primary school, particularly in the upper classes.

Vocabulary Board in Science teaching:

As in other subjects science also has a good number of words which are difficult for the pupils to understand. Some of them are ordinary difficult words and others are technical or scientific terms. While teaching, these words will have to be used. Recent studies have indicated that careless use of words ^{which are too difficult, will come in the way of the effectiveness} ~~difficult~~ of instruction. Gerald S. Craig in his study, in 1927, on 'certain techniques used in developing a course of science for the Horace Mann Elementary school', has clearly felt that there is need for using difficult and technical words in due regard to their age and their vocabulary. S.R. Powers in 1925-26, conducted a study 'on the vocabulary of high school science textbooks'. Further, on the experience



gained in the first study Powers constructed a list of technical or scientific terms, suited to the high school pupils. Pressey Luella Cole in 1924, conducted another study on the technical vocabulary of school subjects. The above studies have indicated that a suitable vocabulary is to be determined in science for the elementary schools. But ~~most~~ ^{recent} of the studies are devoted to the determination of lists of scientific and technical vocabulary for high school children. The results of the above studies make it clear that the problem of determining the technical vocabulary ~~and~~ for the primary stage is all the more important.

In India we are just now making efforts to introduce science in the primary school. The medium of instruction differs from state to state. Each state will have to prepare a list of such scientific words for use. The textbooks must be carefully prepared so that the teachers may have some guidance in the art of using suitable words. The writers must themselves know the vocabulary of primary school children. Then only it is possible to prepare textbooks in science with due regard to the proper use of suitable words.

Experiments in this field are to be conducted in every state and suitable word-lists are to be prepared in each of the regional languages. If books are prepared making use of the words from the scientifically prepared list, such books may help the teachers in the field as real guides, in this particular aspect of science teaching.

Some Special feature in science programme:

No doubt, the science course should be based on children's

experience. But it should also have ^oherence of thought. It is possible to organise the subject around some topics of interest or utility. This gives scope for organising a continuous programme of activities in addition to lecture-demonstrations and practical work. Even if the prescribed syllabus is in the systematic or logical order, the teacher can cull out related topics from all the branches and prepare his working syllabus. It is then, possible to make the pupils feel that they are studying one subject. This attitude will be strengthened if the same teacher teaches ^{all} aspects of the subject. The following may be recognised as the important features of such an integrated science programme in schools:

1. There may be talks on science topics, but they should be usually illustrated talks. Pupils' interest is aroused in the wider aspect of science through such programmes.

2. Demonstration lessons are generally the most popular item of science instruction. In fact it is particularly useful to develop the topic. At the same time it solves the problem of giving as many sets of apparatus to the class as there are pupils. While the teacher is demonstrating the experiments the pupils will ^{not merely} observe and learn ~~not merely~~ the handling of the apparatus but also experience a class room voyage of intellectual adventure. They are not to remain passive listeners. They do observe, infer and reach some conclusion. They may ask the teacher about some doubts and difficulties and may be even asked by the teacher to answer some question or to assist his demonstration table or to take down some diagram. Hence, the class will be active.

3. Teachers' talks and demonstrations ^{should} usually create desired in the minds of the children to do some experiments. In the upper classes; schools may organise some laboratory work to the pupils in addition to the lecture demonstration. The topics selected for pupils' practical treatment must be very simple. A good number of schools may not have sufficient sets of apparatus. They can set different experiments to different children.

4. The children take down some notes in the class. They may also record some aspects of the experiments they conduct. The teacher should see that they develop the proper habits of taking down notes and recording the work done. This can be done from the early stages by regular ~~by~~ supervision. General instructions to the class may be issued on what lines the same is to be written. Their class notes and records may be corrected by the teacher ~~and issue the children~~ ~~realising their mistakes~~ and indicating the way of taking notes. This should be rigorously attended to at the primary school stage, so that the pupils will have good grounding in notes-taking and recording. Some times, the teacher may even dictate some notes if the same is difficult.

5. The English science teachers ^{level} at the primary school, frequently convert their class into a discussion room. The children show great interest in getting their problems discussed in the class. This technique can be followed in our schools also.

6. In England, home work will not be given to children. The parents do not like it. They do not like that their children should engage themselves with the books through out the day and night. But they do encourage their children in various activities. The science

teachers would like to make use of those opportunities and encourage various outdoor and indoor activities. English children can buy good books in the market, on 'How to do little things' for themselves'. In the local markets they can get materials required for their projects. The parents assist them in their effort. The children show interest in observing the sky, home-gardening, keeping pets like, cats, dogs, rabbits, etc. In the rural side they may be interested in bee-keeping, poultry-farming and agriculture. Schools in addition to encouraging those activities, will start science guilds and science societies where pupils will give talks on their projects. This provision acts as an additional stimulus to the pupils for outdoor activities.

The above programme of science teaching is certainly suited to our schools. We have to give a rural bias to the same in the rural schools. In England and Scotland rural science is a special subject to be studied by the teachers in the training colleges.

Conclusion:

Primary Education in India is in a rapid process of expansion. Along with the task of extending educational facilities, efforts are being made to improve the quality of education. This is to be effected by revising the contents, equipping the schools and training the teachers. While revising the content side, the new trend of integrating ^{the} related branches or subjects and ^{the need for} providing opportunity to the primary school children to study science must be borne in ~~the~~ mind. A particular aspect of organising the science instruction is to get

suitable reading materials for children. Children literature in the regional languages is not encouraging. Those that are devoted for science topics are rare. State and central effort is ~~very~~ essential to encourage the production of suitable reading material in science for primary school children.

Science programme is a new innovation into our educational field. At the primary stage we have also felt the problem of preparing suitable text books in science. In England and other continental countries as well as in America, a good number of textbooks written for children of the primary school in science are available. The selection of topic, the organisation of matter, the way of approach, the illustrations, problems and activities set and the get-up will certainly attract the minds of the pupils. A study of those science textbooks will certainly help us to prepare suitable text-books in science for our primary school children.

Influence of science on other fields of learning:

The subject of science is not merely a collection of facts and information. It is a new culture involving knowledge, method, attitude, habits of control, power and the like. It rather helps in the development of the full personality of the children ~~not merely~~ to adjust ^{not merely} to the existing order of society but ^{also} to an ever-changing ^s dynamic society. It helps the individual not merely to acquaint and interpret the present but also for the advancement of the human culture. It enables the individual not merely for the understanding of the nature but also for its control in the interest of mankind.

These potentialities of science do influence the pupils' ability to study other subjects. Primarily, it inter-relates all the other subjects of the school on the one hand, and enforces the correct approach to things ^{on the other.} Such science topics like gardening, bee-keeping and live-stock, handicrafts of various types, the basic or ordinary crafts of basic schools and activity schools are intimately related to science. A knowledge of science is essential for carrying out those operations in the schools. Introduction of science as a separate subject of study in the primary schools, will certainly, make those activities meaningful and interesting to the pupils.⁸

Even such school subjects as language arts, social studies and mathematics are also influenced by the study of science. Science develops in them the correct habit of doing and observing things in an orderly manner. This habit in turn, develops in them the habit of securing the raw materials for thought and organising ideas and expressing them in an orderly way. Correct usage of words, accuracy of expression and regard for sequence of ideas, events and occurrences, proper approach to tackle problems and situations, reasoned thought and judgement certainly, go a long way in helping the language studies. The stories of scientists develop in them a desire to know more about their time and particularly the way in which ~~in which~~ people in those days lived, thought and behaved. This acts as a good setting in their mind both with regard to interest and motivation to study social studies. Similarly the measurement of things in science provides a concrete setting for the abstract topics of mathematics. These possibilities indicate that the introduction of science will wield a benevolent influence on the study of other school subjects at the primary school stage.

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CHAPTER IX.

Selection and Organisation of Science Contents.

The school curriculum represents the major experience of the human race. All those experiences of the race that have played a dominant role in shaping the culture and civilisation, are usually included in the school curriculum. In the early days it used to be formed in a somewhat, haphazard way. The original curriculum consisted mainly of religious experiences. To this were added the language and literature, mathematics and astronomy, history, geography and science, as time advanced. The new subjects entered into the school curriculum as a result of public pressure. These innovations into the premises of the curriculum were intended to educate our boys and girls more and more effectively to play their part worthily at home, in society and in the places of earning their livelihood and to live as better and happier men and women. Thus the nature of our curriculum has been continuously subjected to influence by our desire to assist our children to acquire or develop the habits, skills, interests and sentiments which are essential, both for the well-being of themselves and that of the society. Of the various experiences that go to form the curriculum, are those that have proved to be important and useful to the race and hence deserve to be taught to each succeeding generation. Hence, it is the responsibility of the school to preserve and transmit the traditions, knowledge and standards of conduct on which our civilisation depends. These experiences have been crystalised into systematised

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bodies of knowledge. The pupils find it difficult to assimilate. Hence, it is also the responsibility of the schools to reorganise those bodies of knowledge or subjects taking into account the age, ability, natural interests of the pupils and the way in which they assimilate the same.

According to the age and intellectual ability, the subject is to be graded. According to their interest, suitable aspects of experiences are to be selected. The contents of a subject are to be organised in accordance with the learning process. These two aspects of the curriculum have attracted the attention of the educators, teachers and research workers in recent years. Attempts in this chapter, are however, restricted to a consideration of the trends in the selection and organisation of contents in the subject of science.

The selection of contents for the subject of science for the different grades of instruction depends largely upon the objectives set before us. As elaborated in the earlier pages, though our objectives of science teaching differ in emphasis from grade to grade, we can say that science teaching should aim at the following objectives in general:¹

1. Imparting of functional information;
2. Development of functional concepts;
3. Aiding in the functional understanding of some principles;
4. Developing skill in the manipulation of apparatus, etc;
5. Developing ability and skill to solve problems;

6. Developing certain attitudes and appreciations;
7. Developing certain desirable habits, and
8. Developing their interests.

Keeping the above in view, one can think of selecting contents for the science curriculum. But, there is plenty of scope for subjective influence. Hence attempts are made to evolve a scheme for that purpose, whereby, as far as possible, no subjective element can creep in. The Thirty First Year Book of the National Society for the Study of Education has emphasised that the programme in science for the primary and secondary schools may be directed towards developing meaning for a selected group of major generalisations or concepts of science. Craig developed a technique and determined a group of those concepts.² Later, Downing determined a list of the functional principles of science for different age groups.³ Robertson developed a technique of his own and selected a list of 113 principles which can be taught for the children of the primary school. ~~children.~~

Contents for the Primary School Science:

The above studies are carried out in America. They are mostly directed towards the selection of contents for primary school science in terms of basic concepts and principles. They have taken, in doing so, the interests of the children into account. It is essential to take into account the children's needs also in order to determine the contents of the science course. Usually their needs fall into three categories - intellectual, motor and social. While making selections for the different grades of primary school these developing needs of the children must be borne in mind.

In England, Wales and Scotland, attention is not being given

so much, to the American research studies mentioned above. Rather, they trust their "Common sense". They view the growth and development of the child as a whole organism, and look at science only as one facet of this development. It means that science programme should be developed as an integral part of the school programme. Though there is good lot of traditional bias in this aspect of their ideology, it becomes clear that the nation does not mechanically view the problem of selection. Further, it becomes clear that the centre of interest in that country is gradually drifting from the child to the society.

We notice that, in India, ~~that~~ ^{Basic} general science is being introduced in recent years. But the ^{Basic} Education Scheme which originated as early as 1938, had included science for children from 7th to 14th year of age.⁴ The General Science Curriculum forms the natural environment of the children to which they have to adjust. The subject is to be taught not separately for itself but, as a necessity to learn the central craft which is the medium of education in the basic school. There ~~are~~ no separate criteria for the selection of contents. Rather, the facts, concepts and generalisations as well as attitudes, appreciations and skill are to be taught as and when necessitated while learning the craft processes. No doubt, there is a separate syllabus which includes various aspects of the subject. Those aspects of the subject or the contents are to be taught as and when they are found necessary while learning the craft processes. In other words, science is only one of the facts that communicate with the common social craft. Hence, this trend in its own way is unique though comparable with similar trends in

Britain and in America.

After studying the trends in determining the contents of the primary school science, one does not fail to feel that a really useful and objective type of determination of the contents of the primary school science can be effected by taking into account the principles involved in the above three trends. We have to take into account the following aspects in determining the course contents:-

1. Children's age and conceptual ability;
2. Children's interest;
3. Children's needs and growth pattern, and
4. The extent to which the particular experience has played a role in the evolution of human spirit.

It is possible to determine separate lists of contents on the basis of each of the above four principles. Then, it is reasonable to prepare a compromise list of contents to form the actual primary school science curriculum.

Contents of the Science Curriculum for the Secondary School:

The nature of the children of the secondary schools differs from that of the primary school children just as the ^{nature of the} latter differs from that of the pre-school children. This difference necessitates the difference in the criteria for the selection of course content. If the emphasis was on the child's needs and interests in selecting the contents for the primary school children that emphasis shifts to their social needs at the secondary school level. To some extent

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the interest of the subject also becomes important. The studies made on behaviour, interests and growth characteristics point the way towards utilising other significant factors in selecting the contents for high school science. The children at that stage will be going through a period of rapid growth and their interests are centered in sports, team work, adventure and mystery. They exhibit strong desires to explore and win the appreciation of others. They show keen interest in their personal worth and strive hard to do original work or research. They develop wide interests in the community concerns. They also exhibit their eagerness to study books and improve motor skill and ability. They try to develop ideals and attitudes. They also seriously take to vocational and avocational pursuits. Naturally, the contents of the curriculum must be selected such as to ensure proper scope for the development of all those aspects of the personality. Basing on the above nature of the adolescents, the following factors have been enlisted and they may be borne in mind while prescribing the curricular contents:

1. Development of desirable social ideals involving concepts and principles of science;
2. Inculcation of scientific attitudes and methods;
3. Helping them to live scientifically;
4. Providing for the full growth of their ability;
5. Helping them in their intellectual understanding of the environment, and
6. Satisfying their needs and interests.

Every aspect of the six factors will demand the inclusion of certain topics. When the science curriculum is made by selecting contents



on such scientific basis certainly it goes a long way in the realisation of our avowed objectives.

In England, Wales and Scotland the public interest to-day, has centered round secondary education. But the public evince their interest mainly round the structure, organisation and status of secondary schools. The technical aspects of education are left to the teachers and educators. The changes introduced in the secondary education by Buttler's Educational Act of 1944, were primarily motivated by political and social reasons and only secondarily, by the Educational or Psychological reasons. This statement is found true when applied to the evolution^a of the existing curriculum of the secondary schools. Though the organisation of institutions underwent great changes, the curriculum of the schools particularly in general science, remains mostly as it was before the introduction of the above reform in the field of secondary education. Though problems related to science curriculum are being tackled both by the University Departments of education and by the National Foundation for Educational Research, their recommendations are not so readily applied in the practical field. Moreover, such studies in Britain are sporadic and few when compared with the published studies in America. The Universities and other Examining Boards have not subjected their courses of studies prescribed for the General Certificate of Education Examination, to evolution^a in the light of the reported concerned studies, made in Britain and elsewhere. Though Committees consisting of University subject experts, teaching staff of the secondary schools and other persons interested in education, make selection of contents, they are influenced more by tradition than by research

findings. It is not that they dislike modern developments or educational research; rather they like and respect traditions more. This tendency has been observed by Dr. George Z.F. Bereday and Dr. Joseph A. Lauwerys, as expressed in the Year Book of Education - 1958. They feel that as a result of the above national character, the curriculum is being influenced by traditions. As a result of their conservative way of making curriculum, inertia has resulted; teachers and schools have fallen to that age-old groove⁵. This inertia in the educational practice is not so much tackled by the public since their social theory or existing institutions support it. In this Year Book of Education - 1958, published by the joint effort of the London Institute of Education and the Teachers' College, Columbia, contributions from both sides of the Atlantic are included. One can naturally expect that the traditional view of Britain will be influenced by the more modern research mindedness of the Americans. Naturally, the Year Book focusses on three important aspects of curriculum making, namely:-

1. Theory of Curricula;
2. What should determine what is to be taught? and
3. Where ^{should} sovereignty reside in curricular matters?

Though the course contents are selected mostly by traditional method there is good lot of freedom to the English/Science teacher. He has full freedom to ~~the English~~ alter the curriculum, to adapt the curriculum and even adjust it to the particular needs of the society and children. Naturally the progressive aspect of curriculum though denied by tradition is restored to some extent by the

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freedom in the profession and good commonsense and adaptability on the part of the teachers. This is exemplified by the way in which they organise the science course in the different secondary schools of the country. Though they make use of the syllabus of the same Examining Boards, each type of school prepares its own working syllabus. In the Grammar School emphasis is laid on the academic aspect of the syllabus. Whether it is in the general science or in the special sciences, this aspect is restricted only to those who are going to specialise in science in the University. In the syllabus of the science course meant for non-science specialists, the science teacher does not lay emphasis on the academic aspect but on the social and humanitarian aspect of the curriculum. This adaptation is possible mainly because, those non-science specialists do not take up examination in science. They can take examination only in the subjects in which they want to specialise in the University. In the Secondary Technical Schools they not merely adapt the syllabus to the particular needs of the children but even treat it with a different approach. At the end of the school course there is an internal examination with some amount of external control. This facilitates the adaptation of the basic syllabus to the different abilities and differing needs of the pupils who are studying different vocational subjects. In the modern school where the general level of intelligence is comparatively low, there is no examination of a public nature at the end of the school course. Moreover, many of the students wait there only to complete their period of compulsion so that they may leave the school and enter the life. The teacher may use the syllabus prescribed by any examining board but he adapts it

to the particular pupil's ability, interest and needs. Some pupils who are very weak, will have a course of science such as the study of the parts of some machines with which they are interested ~~and~~ and in which field they would like to get employed. It must be remembered that it is not ^a vocational subject. It is only adapting the basic traditional syllabus to the varying ability, interests and needs of the pupils.

In India education is the concern of the different states that go to form the Republic, except in the case of the centrally governed areas. Each state has a department of education and it looks after education within the state. Within each state Education is centrally controlled. In many states there is a single board of examination to conduct the public examination at the end of the school course. Naturally, one can expect that there will be uniform type of curriculum, faithfully followed in all the schools. So, we have neither the facility for adapting the basic syllabus as in English Schools, nor there is a fund of research criteria to construct a scientific type of curriculum suited to realise the declared goals of science teaching. Studies are no doubt, being undertaken both by the University Teachers' Colleges and by the other Central and State agencies in the field. But, we may have to wait for a long time before we can use them for the purpose. Meanwhile, the curriculum that we used to prescribe resembled till recently, the old traditional academic type ^{of} curriculum of the English schools. In all schools the science teachers had to use ~~them~~ ^{it} without adapting. So we had the unsuitable ~~unscientific~~ type of science curriculum without

that means for adapting the same. In recent years, particularly after the publication of the draft curriculum⁶ by the Central Government for the higher secondary and the multipurpose schools, each State has tried to adapt them^{or} to the particular needs of the schools. But such a syllabus has to be made common to all the schools within the State, as the pupils will have to take a public examination at the end of the course. So long^{as} as there is a single examining board for the whole state and^{in long run} every school is asked to take the same examination, it is normally very difficult to think of a syllabus suited to all. But the Public Examination is only at the end of the four year secondary school course. It is possible at least, in the first two years, to try to evolve working syllabi keeping in mind, some of the criteria mentioned above. This freedom to adapt, will facilitate the science programme in the schools, to get suited to the individual ability, interests and needs.

Organisation of the Materials of Instruction:

If the selection of course contents facilitates the realisation of the objectives of teaching, the organisation of these contents helps the class-room procedure. Further, just as the selection of contents depends upon the objectives of education, the organisation of those contents largely depends upon the teaching techniques. It may even dictate the type of teaching technique to be followed! If the selection of learning experiences ensures the proper means of transmission of national culture, proper organisation ensures the way in which it is^{to be} transmitted. Hence, it becomes clear that the same importance and care we evince, in the selection of

of materials, must be evinced in its organisation also.

After the contents are selected, they are to be organised mainly to ensure effective learning. Even without a scientific attempt to organise the contents, the pupils may be able to memorise facts, concepts and principles of science. Such a type of learning may result in a systematic or proper study of the subject. Yet, it does not influence the development of the personality of the child. To what extent the particular type of organisation does not serve any educational purpose. It should ^{be} remembered that the subject is not taught in schools for its own sake, but for the development of pupils' personality. This fact gives sufficient clue to determine the principles on which the selected contents are to be organised for effective learning. The type of organisation should facilitate and ensure the realisation of the following objectives of science teaching:

1. The functional understanding of facts, concepts and principles;
2. The development of desirable attitudes, interests and appreciations and
3. The acquisition of the ability and skill in problem solving.

The science teachers may become familiar with those factors that enter into effective organisation ~~to organisation~~, to ensure the realisation of the above objectives. Some of the those factors and the underlying principles are elaborated below:

Scope for recurring experience:

The understanding of facts, concepts and principles of science

takes place slowly and with repeated and varied experience. While planning^{for} the organisation of materials, provision may be made for the recurring of experience with facts, concepts and principles to facilitate the enlargement of understanding.

Need for association and patterns of integration:

The logical arrangement of matter or contents may lead to the learning of isolated elements. They may remain as so many pieces of materials not connected in any way. Such a store in the memory is not merely a waste but a positive danger too. They are of use only when they are assimilated in their proper association. Hence the contents may be organised not on a logical basis but on a psychological basis. This naturally necessitates the organisation of materials in such a way as to ensure patterns of integration to emerge as learning progresses.

Inclusion of situations for the development of attitudes and appreciations:

Attitudes and appreciations are usually slow to develop in the individual. They arise and develop when pupils are confronted with situations involving those attitudes and appreciations. Repeated experience with such situations, will help the individuals to make those attitudes and appreciations part of the equipment of their personality. Hence it may be remembered that the desirable attitudes and appreciations do not develop incidentally but as a result of deliberate planning for the inclusion of such situations, while organising the materials of instruction.

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Scope for problematic situations:

The ability to tackle and solve the problems before us does not develop by mere learning a fact~~xx~~ or a principle. Rather, it has to develop as a result of repeated practice in problem solving. It does not develop concomitantly from mere association with science materials. The teacher may organise the contents in such a way as to provide opportunity for practising in the art of problem solving.

After elaborating the above principles, that one has to bear in mind while planning the organisation of contents, it is difficult to say that the best type of organisation shall be like this or like that. Rather, it is more useful to consider some of the trends observed in different countries with regard to the types of organisation of science materials.

The subject centered logical organisation:

When science was studied only by the matured minds and the university students, and when the main objective of science pursuit was the mastery of the subject and the acquisition of the particular discipline, the contents of science were organised according to the systematic or the logical order. The introduction of science to the schools necessitated the organisation of the same in accordance with the laws of learning. But the teaching of science in the secondary schools was merely to prepare the students for the college courses and as such till the beginning of this century, ~~the~~ contents even in schools, used to be organised in the same way as it was done for the college courses. Even to-day, the contents of science ~~are~~ organised

in a number of countries on the same line. The organisation of physics into its traditional and systematic divisions like mechanics, hydrostatics, heat, magnetism, electricity, light and sound is still being noticed. Similarly in Chemistry the contents are organised in a logical way into elements and compounds, each subdivided into the familiar pattern of occurrence, preparation, properties, uses, etc. This is true with Biology also. The subject is organised into plant biology, animal biology and human physiology. Such a type of organisation may be suited with specialisation in science.

As we go higher and higher in the educational cadre, the centre of interest gradually shifts from the child to the subject. Therefore, such an organisation of matter may be justified with regard to the University science courses. It may also be justified to organise the science course on that line at the top classes of the secondary schools. But, it is proved to be unsound to organise on that line at the primary or the lower secondary classes. As the nature of learning process was understood and the need for making child the centre of instruction became evident, the above method of organising the subject is giving place for a new and psychological arrangement of matter to ensure facility for effective learning. This movement was started in America during the first quarter of this century where as in England it was followed during the second quarter. In India, such a movement is influencing science course at the practical level, only from a few years.

The system of arranging contents psychologically began to be experimented first in the west. The publication of the 31st Year

Book of the National Society for the Study of Education, gave an impetus for this work. After its publication, efforts were made to evolve newer and newer ways of organising the contents. A few of them may be elaborated here.

Organising the contents ~~to~~ and around the major concepts:

The understanding and enlargement of the objectives of science shall constitute the contribution of science teaching to the ultimate aim of education; and for this purpose the subject may be organised around each of the major concepts of science, in such a way as to enlarge the contents around those concepts, at each of the successive grades. This naturally ensures an increasingly matured development of the objectives.

This plan is sometimes spoken as the concentric arrangement of matter. Every year the contents go on extending around each of the concepts concentrically. It is found that this arrangement can be followed for organising any aspect of science contents. The unit around each concept will be simple in the earlier grades and goes on extending and becoming complicated as it extends into the ~~at~~ higher grade, in accordance with the conceptual ability of the children and their interest. This type of organising the contents around some concepts of science and extending and enlarging those contents year by year, has become very popular in India particularly after the introduction of science into the primary schools in Bombay, Madras, etc. This provides a continuous science experience to the children from primary to the secondary stage. In recent years, attempts are being made to reorganise the science syllabus for the

lower classes of the secondary schools also on the same line. But such a type of organisation has not become popular because of the existing system of examination, dominated by the university elements. This unpopularity of the concentric arrangement is also due to the existence of specialist teachers in sciences, who would like to teach it, as they learnt it in the College. This technique is not popularly seen in the courses of studies in English Secondary schools. The usual logical method is followed in organising. This is evidenced by their ~~different~~ ^{Science} syllabi, some of which are included in the appendix. It is one of the common ways of organising the course contents.

Organisation in terms of units of environment:

One of the common trends that we notice in the organisation of curriculum in all the school subjects is a growing tendency to organise the contents around the environment in which the individual is living. This kind of arrangement has become most popular with the science curriculum makers. First, attempts were made to organise the contents on those lines ^{for the secondary schools} in general science, later on it ^{was applied} came to the primary school science ^{also}. There is a tendency to organise ^{on this line} the contents of the special sciences also. No doubt, there are certain advantages of such a type of organisation for instructional purpose. Primarily, it facilitates to educate the children for adaptation and secondarily, it permits the teacher to draw plenty of reserve materials from the community of natural environment. Added to these, the teacher has the advantage of adjusting the curriculum to the varying ability and differing needs of children. It

is also possible when organised on the above lines, to ensure the complete mastery of the content materials. The pattern of environmental unit as a device for effective learning can be selected to begin with, from our immediate needs and then, we may go on organising on units based on other needs; this may go on widening within every grade from the individual body to the universe. So, ~~that~~ the first unit can be our body, the next our food. Afterwards, may come the air we breathe, the water we drink, our ^eshelter, heat and light. Our clothing, pets and domestic animals, machines we use, fire, transportation, communications etc, may also be chosen. No doubt, there are other ways of organising the contents on this principle. ~~Anyhow~~, it is possible to organise the major materials or instructions in science, around one or the other units to which the individual has to adjust on the one hand and to learn to control it on the other.

We find the above line of organisation of matter in the curriculum of the schools of America. In England except in the curriculum for modern school, we still have the same logical arrangement of matter. The ~~educators~~ have not devoted much attention to the science programme at the primary school level. In India, after the advent of freedom, the attention of both the government and the public has been focussed on the nature of material of instruction in all subjects, at all grades. Particularly, after the issue of the draft curriculum by the central Ministry of Education, for the multi-purpose and the higher secondary schools, a good number of seminars have been organised to discuss and evolve suitable organisation

patterns for the materials or instruction in science. The recent trends are indicated in one or the state curriculum for secondary schools in the subject. It is included for reference in the appendix.

Organisation around the pupils' interests:

A large number of interest studies have been conducted in America in the second quarter of this century. They were centred round the main task of studying the particular nature of the development of different interests of the children and determining the particular topics of science, suited to those age-levels. This movement in curriculum organisation is clearly reflected in the Forty-sixth Year Book of the N.S.S.E. It is suggested in that book that the curriculum in science can be organised on a practical pattern of spiral grade placement for junior high schools. It takes into account the interest of the pupils of the particular age-group while selecting the contents of science in organising the course around the pupils' immediate personal problems. This arrangement takes into consideration their maturity of interest and the conceptual ability. At the same time ^{it} tries to organise the contents, so selected, around pupils' problems. Certainly, this is particularly a good type of organisation for the lower secondary ~~grades~~ and primary school science courses. But a good lot of investigation has to take place before we can get enough data of reliable nature, to make this a pattern of organisation.

Human Experience as the Unit of Organisation:

The most popular trend in the organisation of curricular

contents in U.S.A. and in the science course for modern schools in England is to organise the science contents around some broad areas of human experience. The following are some of the popular areas around which the materials can be organised:

1. Food and Nutrition;
2. Health,
3. Consumership;
4. Recreation;
5. Safety;
6. Conservation;
7. Vocation.

Though there is a strong tendency among the curriculum makers in some countries, to organise science contents on the above lines, they are strongly criticised in other countries. They are said to be indulging in the act of diluting science into general knowledge. The English teachers will however, tolerate such a type of organisation for modern school children, since they neither go to the university nor ~~do they~~ take up any examination.

Lesson Unit Plan of Organisation:

This is a common type of organisation that one sees in the English secondary schools particularly, in modern school. The principle underlying this type of organisation is that the topic so selected should be a unit of matter for some lessons or should be just enough to be covered in one period. In the modern schools the science teacher prepares his working syllabus by converting the whole syllabus into 30 or 35 units or topics, each of which may be one bit of the subject matter. In America, the organisation of contents is less logical but more psychological. Those units are intended not

for a single period but may be, for more. They are not mere bits of the logically woven curriculum, but materials of different branches of science organised around some major problems or areas. These problems or areas are further sub-divided into learning units, areas of problems. "Pure Water Supply" is a major unit. This is usually sub-divided into learning units like, 'Impurities in water', 'How impurities enter water', 'Removing the suspended impurities', 'Removal of dissolved impurities' etc. It may be interesting to compare the unit plan of organisation ^{with the organisational plan} that is followed in some of the English secondary schools. Reproduction for example, is a unit. If it is a bigger unit, it is again subdivided into teaching units, usually in the logical order. Reproduction may be subdivided into units like meaning of reproduction, organs of reproduction, the germ cells, outline of development etc. It is clear by the foregoing, that there is nothing new in the English system of organising the curriculum on the above principle. It is only the logical division of the topic into convenient units to suit the purpose of teaching. Whereas, the American way of organising the curriculum is more meaningful to children and hence procures their purposeful attention. To render the above purpose stronger, and to create situations that may challenge the learning ability of children, these units are frequently restated as problems. The major unit "Pure Water Supply" is stated as "How do Towns get Pure Water Supply?". This no doubt, is a major problem and can be divided into a number of unit problems, each of which can be covered in one period. Those problems may be like 'What are the impurities in Water?', 'Where do they come from?' 'How are suspended impurities removed?', etc.

The American problemtype is a flexible way of organising the curricular contents. It can be adapted for any teaching technique. When taught by the inductive technique it can develop in the pupils the problem solving ability and skill.

Conclusion:

An analysis of the different modes of organising the contents, indicates certain definite trends. Whether they arrange the contents into units or problems, the tendency is to organise the contents either around some area of experience or around one or the other aspect of the environment. Another tendency that can be observed, is to organise the contents around some major problems of life. These major units and problems are subdivided to suit the purpose of teaching and learning.

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CHAPTER X

Diagnosis and Remedial Programme in Science Teaching.

In the earlier chapters attempts are made to bring out the growing impact of science on human ways of living and the subsequent increase in the demand for science education. Every nation has now realised that science is not merely a cultural subject but also a means through which the pupil's personality has to develop on the one hand and the national economy has to strengthen on the other. Hence it is no wonder to find that every state is spending as much as it could and even more, to strengthen science teaching in the different grades or institutions. Hence it is reasonable to expect a good return for the interest, energy and finance devoted over science education by the state. But when compared with the results of the pupils' progress in other subjects, there is a comparative difference with science education. In 1956, the results of the University examinations indicate that the percentage of failure is maximum in science subjects. In that particular year about 54% of the pupils have failed in science. This failure no doubt, is partly due to the type of teaching at the Universities and partly due to the ineffectiveness of instruction at the earlier stages. Hence it becomes clear that we have^{to} devise means and methods to prevent this national wastage. In addition to^{the} improving science education at the university level we have to pay greater attention for making science instruction more effective at the secondary school level.

Such wastage in science education was even noticed by Professor H.E. Armstrong of England in the closing days of last century. He found that the students coming to him from the secondary schools, were badly ground. The same observation to-day, applies to those that go from secondary schools to university colleges. I will restrict myself here to indicate ways and means of preventing such a wastage at the secondary school level.

The re-organisation of the science programme with a view to provide effective instruction in accordance with the latest principles ^{of} ~~and~~ learning, interests and needs of the pupils and the change in the individual and social responsibilities may result in the removal of this wastage to some extent. But the major cause for this wastage should be elsewhere, i.e., in the ~~interest and~~ ^{attitude} of the pupils. This is to be further analysed into the root cause.

In the beginning of this century it was known to the teaching world that there ~~are~~^{are many kinds} ~~are~~^{are} a good number of individual differences. The pupils differ from one another in their capacity to learn. In a group of forty or fifty there may be some bright students who can easily follow class teaching; but there will be a good number of average type of students who can follow class teaching normally. There may be a number of backward pupils who cannot follow class teaching. It is this type of ~~people~~^{people} that require special treatment. Among the average and ~~the~~^{the} above-average type of pupils some may follow some aspects, and ~~may~~^{they} may not be able to follow other aspects of the subject. They are also the cause of wastage in science education and hence require special treatment.

The above diagnosis indicates that there are two distinct types of pupils who are not able to get the benefit of class teaching to the same extent as the others. They are:

1. Backward pupils who are unable to benefit by the ordinary class room technique of teaching: There will be a substantial number of such pupils in each class. They will be usually about 20% of the total number.
2. Average and above-average types of pupils who cannot follow certain aspects of the subject or who feel unable to benefit by class instruction in some specific area: They will be in large number. 30% of the total ^{number} pupils will come under this category.

The advent of mass education has made it compulsory to retain class system both for organisation and for instruction. Though attempts are being made to fuse these two aspects of education into one convenient cast no effort has been successful to develop into a Universal scheme of education. The Dalton plan, the Howard scheme, the Winne~~tt~~ School and other plans were intended to solve the problem of teaching as many pupils as possible and at the same time, to pay individual attention. Though the general principles underlying those modern developments secured universal appreciation none of those schemes could develop into a state of universal application. Therefore the problem of preventing the educational wastage due to mass instruction particularly, remains as it was.

Reducing the size of the class:

In the ordinary method individual attention is possible

only when the strength of the class ^{is} comparatively small. In the post-war days the strength of the class particularly for science instruction, is reduced to 20 or 25 ^{in U.K.}. This reduction of the size of the class facilitates the teacher to pay individual attention to some extent. This can be tried as a measure to bring down the wastage in science education, even in India.

Special methods for teaching backward children:

In England, Scotland, Italy and other countries the suspected backward children are grouped in one class and the teaching work of that class is entrusted to teachers who have specialised in the methods of teaching the backward children. Such an organisation of class for effective instruction, is certainly an approved measure to prevent wastage in education. But in a small school where there are 50 or 100 pupils the backward pupils may not be in sufficient number to form a special section. It is difficult to have specially trained teachers in every school. Added to these, if pupils are grouped on the ^{principle} ~~like this~~, they may feel inferior to others and may develop undesirable attitudes towards themselves and towards the society. Hence this technique of grouping all pupils that are backward in one section may not be advisable. It may look ^{as if} ~~that~~ that particular section is treated in the school society ^{as criminals} ~~as if to be in~~ a concentration camp, ~~of criminals~~. They may even lose the social benefit of being with the gifted pupils of the school. Yet such a type of grouping for the purpose of effective instruction, is in practice in many countries.

Diagnosis of Specific Abilities:¹

The above suggestions are no doubt, useful in preventing wastage with regard to the instruction of backward pupils. The problem is to be tackled in a different but more scientific way with regard to the average and the above average pupils who have only specific weaknesses. Similar wastage no doubt, were observed in other subjects comparatively early and remedial measures have already been perfected. In language, mathematics and in history they are already in use. The particular difficulty of the individual student, which is responsible for backwardness, is first ^{to be} diagnosed. Then, suitable remedial measures are ^{to be} proposed, following the diagnosis in the individual cases. Results have proved that such a measure to eradicate the educational wastage, is both effective and economical. So, it is essential to apply the same technique for improving the achievement of pupils in science also. The technique of diagnosing the particular difficulty or difficulties of pupils is ~~not~~ elaborated below:

Specific abilities in Science learning:

Treatment for any physical ailment should be undertaken only after proper diagnosis. Without diagnosis ^{we can} neither ~~can we~~ know the particular complaint nor the way of eradicating it. Every ~~people~~ who is poor in achievement may not be weak in every aspect of the subject. It is essential to locate in which aspect he is particularly weak. In science as in other subjects, there are particular abilities that generally go to contribute for the pupils' achievement in the subject. They are called the specific abilities. These

specific abilities are generally the following:

1. Ability to remember factual information;
2. Ability to generalise;
3. Ability to apply principles to problems of life;
4. Mechanical ability. and
5. Scientific outlook and attitudes.

Out of the above five specific abilities that go to contribute for the total achievement in science, attention is focussed on the first three abilities as the traditional examinations usually measure those abilities only. Though tests have been invented to measure the mechanical skill and scientific outlook and attitude, they are not ^{popularly} used. Hence the verdict of traditional examinations ^{will be based} ~~with~~ ^{on} ~~regard to~~ ^{the} ~~above~~ three abilities. So we may consider the first three as the specific abilities that go to contribute towards the total achievement of children in science as measured by the traditional system of examination. It does not mean that we should neglect the other two aspects of the outcomes of instruction. This problem will ^{be} dealt with separately, at a later stage.

Administering the tests for locating the specific weakness of pupils:

To locate the particular weakness of individual pupils, diagnostic tests have been standardised in some of the school subjects, like English, Arithmetic and History. Attempts are being made to construct similar tests in other subjects also. In science pioneering efforts have been made in America. But they have yet to become popular.

Diagnostic tests in science should include atleast the three types of tests, each type intended to measure one or the other specific

ability. After administering the tests to a group of pupils who are suspected to be backward, their performance in each of the abilities may be measured by the scores they get. The scores they get will also help us to locate in which particular ability or abilities each student is weak.

Remedial grouping:

Diagnosis indicates the particular weakness of every pupil. Pupils with similar weakness should be similarly treated. In other words they must be similarly instructed. Therefore for instructional purpose they may be grouped on the basis of their specific weaknesses. All those pupils who are weak in one specific ability may be grouped together. So, there will be as many groups as there are specific abilities. These groups which are organised for purpose of instruction, in a particular way, to improve their particular ability, are technically ^{known as} remedial groupings. The success of our subsequent coaching largely depends upon the correctness with which we have diagnosed and organised those remedial groups.

Remedial Programme:

After the organisation of remedial groups by a process of scientific diagnosis, the method of treatment becomes clear and evident. Each remedial group with a specific weakness is to be similarly instructed. This technique of instruction depends upon the particular weakness of the group. If the remedial group is weak in the ability to remember factual informations, a lecture demonstration technique or reading assignment technique is generally recommended. Similarly

exercises in inductive reasoning may be employed as the technique of instruction for a group that ^{is weak in} has _^ the ability to generalise, as ~~the specific weakness~~. Deductive reasoning exercises are suited for that group which is weak in the ability to apply principles to problems. Similarly, for treating other specific weaknesses, suitable remedial instructional techniques may have to be employed.

Remedial Programme only temporary:

Medical treatment for any ailments is only for a short time. If it is continued for more than the required period, the very medicine may act as poison. It is true even with the remedial instruction. It is not a normal event in the life of the pupil. Naturally the treatment shall cease as early as possible. After the pupils indicate that ^{they} have improved in those particular abilities in which they were weak, they become normal and should be treated along with the other pupils for instructional purpose.

A very effective tool to prevent wastage:

The alarming wastage which we are having in science education at different grades of instruction, particularly in the secondary schools, comes in the way of our national progress. The heavy failure retards the work of producing the requisite number of technologists and technicians to man our industries. The progress of our industry is largely responsible for the strengthening of our national economy. So, the wastage that we observe in science education should be viewed as a flaw in our educational system and as a drawback that puts back our national economy. A country-wide and continued failure in

science education, becomes naturally the Nation's serious concern. Individual states may not feel the magnitude or the wastage to such an extent. The Central Government will have to take serious notice of this wastage and devise and sponsor effective steps to prevent the same.

Immediate responsibility:

At present, there are no diagnostic tests standardised in any of the Indian languages. Even those tests which are constructed in U.S.A., cannot be used here as we have different syllabus and different cultural environment. So, it is necessary that we must construct and standardise diagnostic tests for Indian schools both in English and in the various regional languages which are used as the media of instruction in the secondary schools. Further, teachers should receive special training in the art of administering those tests and interpreting the scores. Training will also be necessary in the remedial coaching. Since a single class may have to be divided into a number of remedial groupings, and extra staff may be required. Though we have to incur additional expenditure on the above items, it will certainly prevent the wastage which is many a time more both in magnitude and in effect.

Remedial coaching sometimes may be very difficult to organise in small schools. Under such circumstances all the schools or the schools in ^aparticular locality can think of organising a central scheme of remedial programme.

The implications of the above scheme for ordinary class room instruction:

The work of standardising diagnostic tests in science may take some

time. Afterwards it may take some more time to become popular. Till then the science teacher ~~can bear the principle that they~~ can help a great deal to prevent wastage in science education, by their intention even to roughly understand the particular difficulties of pupils in science and ^{by} their willingness to remedy the same.

The science teacher can construct his own roughly standardised or unstandardised diagnostic tests for his class purpose. By administering the same, he can diagnose the particular weakness of individual pupils. With this knowledge, he can pay attention individually, while he is teaching the class, to remedy those defects. Therefore, a rough and ready diagnosis of the weakness of the pupils followed by individual attention while teaching the class, will certainly go a long way to improve science teaching on the one hand and to prevent wastage on the other.

In a bilateral school at Bristol (Aston Bilateral Secondary school) all the backward pupils of the class were grouped into one section. A specially trained team of teachers were entrusted with the work of teaching that class. The teacher, in charge of science instruction to that class, was an experienced master. While teaching the class, he selected particular pupils to answer particular questions or ^{to} get particular experiences. He seemed to have a knowledge of the particular weaknesses of pupils. The Headmaster told me that that arrangement was yielding good fruits.

The Aston school experiment is an interesting illustration in modern educational practice, particularly, as it provides individual

attention to pupils. This may be tried in our secondary schools to improve the achievement of backward pupils in science and thus to prevent wastage in science education. But this suggestion does in no way minimise the need for a movement for scientific diagnosis and remedial programme through suitable techniques.

Science instruction for the Backward Pupils:

An interesting aspect of Scottish science teaching is the special interest the teachers take in the backward pupils. The syllabus prescribed for the junior secondary schools (for pupils ^{of} 12+ to 15+) is the basic syllabus for the whole of the country. The schools are free to adapt it to the varying levels of intelligence of pupils. If the pupils are very low in intelligence too drastic adaptation of the syllabus will be needed.² This naturally undermines the very object for which it is prescribed. Even if such drastic modifications are effected, the result will not be encouraging if the subject is taught in the same traditional method. Moreover, as the school leaving-age is raised, the country has adopted age principle for promotion of pupils from primary to secondary schools. They cannot send boys and girls from grade to grade without proper grounding. This is particularly true with regard to the backward pupils. Their backwardness in achievement becomes more and more apparent as they advance from grade to grade, ^{since the} ~~as the~~ wealth of experience to cover, goes on increasing both in quantity and in complexity. Hence the schools seriously make diverse approach to the solution of the problem. Both in England and ⁱⁿ Scotland pupils are streamed out into different groups on the basis of their ability, to suit instructional

procedure. Some of the recent practices in that direction and the principles that underlie those practices are elaborated below:

Concrete experiences instead of abstract ones:

Backward pupils are usually slow learners or learn very little when they are taught verbally^a. Hence, lecturing does not benefit them as they are poor in their ability to think in terms of abstract ideas. They show no interest in such learning and even if it is procured somehow, soon it gets diverted. Such pupils do get some benefit when concrete situations of experiences are provided. Science has plenty of such situations. The teacher can make use of such concrete materials to illustrate abstract truth. This technique of teaching abstract concepts and generalisations of science through concrete situations is very popular in Scotland.

Learning to handle apparatus, household instruments, etc.

Every boy and girl will have to use a good number of instruments and service devices at home in their daily routine. Backward pupils will be generally very much interested in handling them successfully to ensure their personal safety. They will also feel proud in handling them successfully. Such exercises, when carefully programmed in the science course for such pupils, will not only procure their interest but also ensure the realisation of the objectives of teaching the subject. No doubt, it is very difficult to develop in them a systematic knowledge of the subject. That aspect is the privilege of the more fortunate and gifted pupils. In English secondary modern schools this technique takes the form of 'set part exercises' to some of the backward pupils.

Following the tract of their fondness:

Backward children may not possess high capacity for learning; but they show strong likes and dislikes. It is an interesting exercise to the teacher to find out the likes and dislikes of those pupils. If their likes are made the avenue of organising the science materials of instruction it is possible to make them learn science better and develop in them some desirable attitudes. The fondness of a pupil in pets can be made the avenue of organising his science experiences and to develop in him the noble attitude for the preservation of natural beauties and situations. Such an approach finds country-wide popularity among science teachers in Scotland, particularly in the junior secondary schools.

Particular problems instead of General ones:

Pupils of moderate intellectual endowments evince more interest in particular problems which are intimately connected with their life than with those that are too remote. The challenge presented to them, in repairing the disordered pendulum of a clock meets a readier response with them than the principles of gravity. The former will, not merely interest them, but even provoke them to participate in the discussions on the principles involved in the phenomenon. Such a particular approach to the general principles of science is found to work satisfactorily in the hands of many of the Scottish teachers.

Sinking with Personal Experiences:

Backward pupils usually show interest in studying science topics with a personal approach. It is found that pupils show greater interest in repairing their pocket torches than when a lesson on electrical conductors and insulators is given. Similar illustrations can be given for other areas of science. This clue is usually made

use of by many teachers when they are teaching a set of backward pupils.

Planning for shorter teaching Units:

One of the symptoms of backwardness among school children, is their inability to focus attention on certain point or topic for a long time. This knowledge should naturally sound the teacher not to plan for longer teaching units. The topic must be short. If a topic can be normally planned in three separate units, the same topic may be planned in more separate bits, thus reducing the span of attention-period. The teachers have observed that by such a method, the topic is taught as isolated units; but they feel that such an approach, at least, makes them learn some aspects of the topic. They also feel that their connection will however, be realised by those pupils a little later.

Lowering the Vocabulary Load:

It is established by many research studies that the backward pupils will be generally poor in language ability. Naturally, when difficult and technical words are used frequently, while teaching, they fail to develop concepts of things, events and situations, even though they can easily understand them. If those things are taught using simpler and more familiar words, they can understand those things, events and situations more readily. Hence, their own related experiences which are within their language ability, both to express and to understand, will form some of the ways by which the approach to the subject is sought. Discussion exercises are also got up to provide them opportunities to improve their experiences in their own language. After this stage, the lesson proper, that is based on the above preliminary activities, will be taught. Graphical and pictorial illustrations are also used to overcome the difficulty of language, statistical concepts and technical terms, while teaching science.

~~Difficult and technical words are used frequently, while teaching.~~

In the foregoing paragraphs some of the Scottish techniques^t of teaching science to the backward children are elaborated. An intelligent teacher can think of many more ways of dealing with them. What is required in such cases, is a little more freedom for the teacher. Though the techniques and approaches described above, are equally of use to Indian science teachers, the presence of an external examination which is the goal of all pupils, will come in the way of putting them to practice. So long as the common examination is to be faced by all the pupils and schools alike, the teachers may find it difficult to resort to such useful techniques. But, in the first three years of our secondary school there is no fear of an external examination. The teachers can think of adopting such techniques. As the examination system undergoes changes so as to provide more and more freedom to schools and teachers, the problem of teaching the backward will attract the attention of teachers. One may feel that it is foolish to teach them by an unsuitable technique, because of the examination. No doubt, this is true; but the other face also is true. Until the present system of examination gives place for a more benevolent type of examination and until ~~the~~ undue importance to examination is reduced, the teacher need not neglect the ~~more~~ unfortunate individuals. They can bear in mind the above principles and try to assist them in as many ways as possible, to make them learn better. Let us feel that it is a moral responsibility on our part to assist those unfortunate individuals to learn better. This attitude of sympathy and ^{the} desire to help them will certainly, inspire ^{teachers} them[^] with

many more means and methods of teaching them science, inspite of so many difficulties in the way.

~~Science Teaching for the Gifted~~: CONCLUSION

With regard to the above mentioned specific abilities in science there are differences among science methodologists. Victor H. Knoll in his work entitled "Teaching of science in Secondary schools", thinks that the specific abilities of children are located in the nature of the subject itself. He says that they pertain to the different fields of the subject, like hydrostatics, magnetism, electricity etc.³ Others feel that it is not at all possible to provide remedial programme on specific ability basis. In this connection it must be remembered that it is the interest that is responsible for effective learning. There is reason to believe, that interest is distributed not according to the nature of the subject as a whole, but according to the nature of learning processes or pupil's experience. My attempt to indicate the specific abilities as above is based on interest of pupils.⁴ When I administered a questionnaire to 33 science teachers of varying period of experience, as to which aspects of learning go to form the total achievement in science, the above listed five abilities were considered as important in ^{the} order of their listing. Yet, further work is needed in the field to locate the basis on which the specific abilities of science learning are to be determined.

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CHAPTER XI

SCIENCE EDUCATION FOR THE GIFTED.

In a group of forty or fifty there will be a small number of pupils who are endowed with a high degree of intelligence. They can easily learn what is ordinarily taught in the class. They may even feel dissatisfied with the type of instruction that is imparted. They may be eager to learn more. Even the technique of instruction may require a change. If they are to sit and learn with the ordinary pupils their gifted nature may not find suitable opportunity to develop. Those children are the gifted few, who, in later years are going to become the thinkers, leaders, discoverers and designing engineers and technologists. They are of great help both for the progress of mankind and for the advancement of industry and technology. They are responsible for the progress of human spirit, culture and civilisation. So, it becomes the responsibility of the schools to provide education suited to their ability. Otherwise to that extent the pupils fail to benefit. The state will not have the benefit of their gifted nature. Above all, the amount of energy and interest of the state devoted to the cause of education will not yield the result in due measure. Hence, it becomes clear that it is another type of wastage in education and requires careful and deliberate handling to prevent the educational wastage, caused by the neglect of or the lack of suitable treatment to, the gifted children. This in reality, is as serious a problem as that of the backward children. The nation should view them as two faces of the single

problem of providing education according to their ability. If the maximum return in the educative process were to be had, the education of both the gifted and the backward are to be treated as equally alarming faces of the problem. Proper measures are to be taken to prevent the wastage due to each face of the problem. Just as it is necessary to take care of the backward pupils, it is also necessary to conserve the talents of the gifted pupils.

Conservation of the Talents not a new Problem:

The problem of conserving the talents of the gifted is more vital to our survival today, than it was at any other period of human history. Yet, the idea is as old as the Greek and Roman civilisation. Xenophon, more than two thousand years ago, had a good insight into this problem. In his 'Memorabilia' he has elaborated how Socrates used to identify and treat the gifted. While providing training for leadership, he has explained the technique¹ Socrates used to identify and conserve the talents, as follows:

" He judged the abilities of the people from their quickness in learning the things, from their remembrance of what they learned and from their desire for learning all those branches of knowledge that help to manage a family or an estate and to govern men and their affairs with success. He thought that such people will not only make themselves happy but assist others also to become happy."¹

No doubt, Socrates had his own technique of measuring the ability of people. For nearly two thousand years after him, nobody tried to evolve a better technique of identifying the intellectually gifted individuals. It is only in recent years that a scientific instrument

In his
was invented by Lewis M. Terman. "Genetic Studies of Genius" he states
that:-

" A nation's resources of intellectual talent
are among the most precious it will ever have.
The origin of genius, the natural laws of its
development and the environmental influences
by which it is affected either for good or evil, are
scientific problems of almost unequalled importance
to human welfare".² - (1925)

He has clearly indicated that it is essential to find out the gifted pupils and give them the opportunities that develop their talent and at the same time, pave the way for human good. But when Terman wrote the above passage the educational world did not know to what extent genius can be created or destroyed by a right ~~xxx~~ or wrong training. Within three decades after the publication of his book we have made phenomenal stride in all the areas of educational research that will throw light on the above problem. In fact, it is realised by educational thinkers that more progress has been achieved in these three decades than the mankind could achieve during the past two thousand years or so. It is but natural that we should count rapidity in our progress not in terms of generation but in terms of days and hours in the space age.

Who are Gifted Children?

We may say that one is gifted, as Socrates did, because of his quickness in response, ability to learn and desire for knowledge. But it is normally difficult to locate where exactly that gift is. Yet efforts are made to postulate some working hypotheses to define all ~~knowledge~~ individuals who may belong to that category. Samuel Bloom

in his book "The early ~~Manifestation~~ Manifestation of Potential Scientists", states that the characteristics of pupils gifted in science, are quite distinct and can be identified. According to Bloom, such children possess a high degree of intelligence which can be measured by standardised intelligence tests; they also exhibit high mathematical ability, high verbal ability and high manipulative skill or ability to use their hands.³ Maccurdy in his study on the 'Characteristics of the Superior Science Students', conducted a rigorous and detailed investigation of 600 'science talent search winners'; compared them with College Controls, over 120 I.Q. on a 300 item inventory. This inventory was with regard to their personality, attitudes, interests, activities, family history, associates, science teachers and decision to be a scientist. He observes that a gifted student will have certain qualities like leadership, self-control, curiosity, national mindedness, intellectually complex, non-gregarious nature, scholarly tendency, competitive spirit, eagerness to read and a few other characters.⁴ It may be possible to locate such pupils in the school as a result of our careful observation. Bloom's technique of identifying the gifted children is more accurate and can be readily applied. Tests for locating are available and hence easy to pick out the gifted children. It is estimated that those children with the characters determined by MacCurdy will usually form the upper 10 per cent of the group. In Soviet Russia the so called gifted pupils, are quite different in nature. Talent to the Russians, means 99% of the population and not 5, 15 or even 25%. It is only 1% of the student population who are unable to profit themselves from an academic programme, because of

their physical and mental defects. Hence they carry all students through the tenth grade which is equivalent to the 10th standard of the Secondary School in our new set up. A very broad front is given to the academic programme. More students are being trained to universities and higher education institutions than they could take.⁵ But there is a tendency for permitting only the ablest to go to the university and for this purpose to effect diversification at 13th or 14th year. Yet the above fact clearly indicates that a huge number of pupils go to universities to become technologists. A still greater number of pupils go to 'technicians' to become technicians. This is how Russia is able to produce a huge army of technologists and technicians for the research, industrial and defence programmes. It is this aspect of Russian education that prompted the Western Countries, particularly U.S.A. and U.K., to think of conserving the education of the gifted children to compete with Russia in the production of technologists and technicians. As a result of their aspiration the public and the leaders of the country look to the schools to help them. Naturally the schools attach importance to conserve the gifted, particularly to provide them enriched courses of study in science.

Identification of the Gifted:

At present, there is some sort of arrangement in most of the countries to identify the gifted pupils either in the beginning of the secondary schools or a little later. But this age of entering the secondary schools differs in different countries. In England the secondary education begins at 11+ and in Scotland at 12+ . But secondary schools admit children in India after 7 or 8 years of

primary education. In America the junior secondary schools admit pupils at the age of 11+ or 12+. But there is an equal number of schools that admit children at 13+ also. In Russia there is ^{an} incomplete middle school stage between primary and complete middle schools. The education is organised in that country on 4-3-3 plan. So, they will provide 10 years of education before the pupils could proceed to university or technical colleges. We can consider that the secondary education begins in Russia at 13+.

In America, the existence of a gifted child in the secondary school was practically neglected. The democratic ideology of the country did not ~~like to have~~ ^{support} social or intellectual distinction that may lead to stratification. Equality of opportunity was too frequently thought to mean identity of opportunity. But the country has realised that such an ideology will lead on to wastage of talents, which is dangerous to social progress and national economy. The Secretary of the Educational policies Commission has stated in his report on 'Education for all American Youths' in 1944, that a very large number of pupils in the American Secondary schools ~~are~~ not getting an education, fully suited to their abilities, interests and needs. He also notes that many youths who could advantageously use more education than they are receiving, are not getting it because, cost-free schools of an approximate type, are not available to them.⁶ Though the idea of differential treatment for children in the schools is not liked they do accept nowadays that "the right pupil should receive the right education from the right teacher" or that "the individual should be placed in the position appropriate to him". Now, an elaborate system of guidance programme has developed in the country. Appropriate

and scientific technique has also been elaborated. Usually the junior secondary school serves a platform where the pupils are screened to identify their particular interests, abilities and attitudes. In the comprehensive high schools the exploration is carried out at the same age level. The pupils are advised on the basis of the results, to take up particular courses of studies. The work of identifying the gifted is part of this educational guidance programme. Usually, experts consider that the gifted will be gifted with regard to motivation, interest, personality, social factors, attitudes and capacities. Suitable tests are developed and are popularly used. As a result of the interest shown by educators and psychologists, guidance programme and conservation of talent have occupied the single biggest column in the educational literature and the press.

Methods of selection or allocation of pupils to the secondary school, best suited to them, have been in England the objects of experimentation since the system of free places were introduced. After 1944 the work of diversifying pupils to different secondary schools according to their ability, interests and needs, made the selection process an improved technique that yielded reliable results. The local education authorities have exhibited remarkable uniformity in the administration of the test. But there is great diversity and variety in the technique of assessment.

The English technique of selecting the gifted is not as much complicated as that of America. It shows variety and flexibility. Emphasis is placed usually on intelligence tests and on tests in English and Arithmetic. Schools records related to pupils' interests,

attitudes and progress, may also be consulted. Interviews are also held. Usually the top 15% go to the academic grammar schools, another 15% go to technical schools and the remaining students go to the modern schools.

In India the pupils are expected to select their courses of studies in accordance with their ability, interest and needs in the secondary schools. For this purpose the country is in favour of having a regular system of diversification of pupils at the beginning of the secondary education stage. Those who have very high I.Q. may go to take up academic courses leading on to the University Education. Those that are not so highly gifted but have aptitude for mechanical skill, may take up vocational studies. In many states the identification of pupils for science course takes place in the second year of the High school, i.e., in the 13th or 14th year. The identification that is in vogue today, is too simple. The achievement of the pupil in the previous year in science subjects is taken into consideration in identifying the gifted children for science course as a selective subject. However, in recent years the diversification mechanism is being developed on objective lines. Along with that, studies in guidance programme are also being undertaken. Beyond these preliminary efforts that are ~~in~~ progress, no special attention is being devoted to the problem.

Programme for the Gifted:

The teachers instructional programme is to be prepared with due regard to the individual differences. No doubt, any teacher will find this job difficult if not quite impossible. Attempts are

limited to make the instruction appropriate to all individuals because of the following difficulties in the way:

1. Excessive class size;
2. Lack of materials and equipment;
3. The teachers' human limitations and
4. Some unrealistic theories of democratic education.

In England, it is usual at 11+, to identify the gifted by an examination followed by interview and reference to pupils' school record. Those who are identified as gifted will normally possess high academic achievement and high I.Q. They are shown as the grammar school children. They will possess an I.Q. above 120. Later, in the 3rd form of the grammar school, an attempt is made to search for talents in science and other subjects. Those that are ~~identified~~ to be gifted for science education, usually take up science for specialisation. At 16, they will generally take the G.C.E. Examination, ordinary level, and the real search for talents in science takes place after that. According to their talent in the different aspects of science ~~xxxx~~ they will be advised by the teachers, to select subjects for their specialisation. Usually such students who are specialising in science will be very few in number. In many of the grammar schools there will be 5 or 6 pupils of that sort, in the 6th Form.

University courses of studies, prescribed for G.C.E. are intended to provide for 3 distinct types of science talents. The syllabus for the ordinary pupils, the syllabus for advanced level, the syllabus for scholarship level - are in reality, courses intended for three different, but graded types of ability. One may take the ordinary level

examination and then take advanced levels. But a good number of pupils who are gifted take up advanced or scholarship level papers. The latter course for the examination is intended to assist gifted pupils by awarding state scholarships. So, a student can take up any of the above courses according to his talent. The schools provide for all these types of pupils ^{with} separate instructional facilities as per their particular requirements.

Even in the programme of correlated activities there is a differential treatment for the gifted. They will be asked to read advanced books in the subject of their specialisation. In the laboratory, they will be given exercises that are suited to their level of intellectual ability and mechanical skill. Such pupils will be asked to take leading role in the school science club and even to guide the proceedings of the same.

A special feature of the instructional differentiation for the gifted, is in the programme of special assignment to be made by the teacher. They are asked to read books on the subject to ensure proper provision for the satisfaction of the ⁱ eagerness of ~~the pupils~~ intellectual interests. A pupil of the 6th Form of a grammar school may be asked to study books usually studied at the university level. But, the teachers do not seem to think of finding out whether those books are suited to those students. They trust that what an ordinary pupil will have to read at the University, is to be read by the gifted few at the grammar school level.

In America, attempts are being made to keep in ~~which~~ with the talented science pupils while the curriculum is being programmed.

Books are selected and school science schedule is drawn up with due regard to the gifted. When assignment is made for further reading they will take into account the requirements of the gifted. The gifted children may have an ambitious syllabus or may be permitted to cover the ordinary syllabus earlier. The activities related, and the laboratory programmes are designed to meet the needs of their superior intellectual and mechanical abilities. Research workers in the field ^{have} devoted attention to study various aspects of the programme for the talented. While determining the type of books suited to those children of superior science ability, certain special features are located by objective means. Roy, C. Rice in his book entitled 'Trends in the curriculum and instruction of ~~Physical~~ Sciences in the Secondary Schools,' says that the gifted children may be asked to read such books that possess the following facilities:-

1. Books that provoke thinking and discussion;
2. Books that develop interests in the methods of science;
3. Books that stimulate further reading and reference to source books;
4. Books that are devoted to articulate and elucidate scientific concepts and principles;
5. Books that suggest fresh problems;
6. Books that create an insight into social problems and their implications to science;
7. Books that are based on authorities;
8. Books that present the controvertial matter without any bias;
9. Books that indicate enrichment materials;
10. Books that are written in a good literary style;
11. Books with worthwhile themes and
12. Books of lasting value.

Though the above features ~~are~~ intended to determine good books for all students, certain features are specially intended to serve the additional needs of the gifted.

Need for specially trained Teachers for the purpose:

There may be one or two science talents in a class. It becomes naturally impossible to provide a special teacher for them. Even to send them to another institution or to group all such pupils into one section may not be possible because of administrative and organisational difficulties. What one expects is that the teacher may pay particular attention to such pupils. With regard to the subject matter the teachers must have studied more than the ordinary teachers, if the education of such boys is to be entrusted to them. Because, some of those gifted may ask questions now and then, which the ordinary teachers may be unable to answer. Further, the teachers may be insisted to have a training in counseling and guidance programme. Above all, they must have a knowledge of the type of science programme to be designed for such pupils. It is possible to train some of the teachers of science in the above aspects in the various in-service training camps that are being conducted. The Central Ministry should organise such training courses both at the central and at the state levels.

Science Talents at the Primary School Level:

In America, there is a growing trend to identify pupils' talent in science at the earliest possible opportunity. A concerted effort is being made to develop various test - instruments to locate

special attitude or interest in science. This concern has been necessitated by the shortage in research, engineering and teaching personnel at different levels. This tendency has received added impetus by the spectacular achievement of Russia in the exploration of the stellar spaces. In a capitalistic country like America, the industrial magnets who require more and more technologists to man their industries, will put pressure on the administrative machinery to develop the science talents in the children to the maximum amount.

How far can this American concern can help their adventures in the interplanetary and stellar space, is a doubtful matter to predict. But the tendency for the early discovery and development of science talent could certainly prove to be a valuable trend. But the above concern involves huge amount of additional expenditure. In America teachers, parents, school boards and others are making efforts to raise money to purchase adequate equipment to their elementary school laboratories. The parents also take particular interest and care to supply to their children at home, with scientific toys to play (study). They also supply to their children chemistry kits, weather and electricity kits, magnetism kits and some of the common and simple machines.

Science is being taught in the American elementary schools since the publication of the 31st Year Book, of the N.S.S.E. In their elementary science programme emphasis is laid on the activities with toys directed towards a specific purpose. This aspect of the ^{programme} has been partly responsible for the development of the new technique of

teaching science in that country namely, the problem method. While manipulating the materials the children will come across a number of problems. They will have to solve them before going further. There is the teacher to assist them. This way of living in school develops problem solving method and attitude in them. And so, the American boys and girls are comparatively at an advanced stage in this respect, over their continental equals.

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CHAPTER XII

Trends in the Technique of Teaching Science.

Teaching and learning are two aspects of education. The teacher teaches only when the pupils learn. This concept has led to study the principles underlying the learning process and to make them the bases for the formulation of the principles of teaching technique. The various maxims of method, the laws of learning, the nature of the interests of pupils at different age levels, the purpose of setting a goal before them, and the way in which we have to motivate them are some of the basic principles that go to shape a scientific technique of teaching. The Technique becomes scientific because, it is based on the objective laws of learning and other principles of child nature and behaviour patterns. But this technique has to operate not with inanimate objects but with children^{who are} growing, reacting and developing in nature. Hence it becomes clear that even the scientifically evolved method may go wrong or may not suit for teaching all boys and girls, in teaching all subjects and all topics of one subject for all times. So the fundamental method though scientific in nature, requires modification. The following are some of the factors that control that modification:

1. The goal set before us;
2. The nature of the children;
3. The topics of treatment;
4. Time allotted for the subject and
5. Organisational facility and professional freedom.

Method is, after all, only a device for the realisation of the goal that is set before us. Naturally, the nature of that device has to change if the goal is to change. This fact is amply exemplified

in the course of the historical development of both the objectives of education and the technique of teaching. When the objectives of education were mere acquisition of knowledge, memorisation was the common technique of learning while 'book and birch' was the nature of the teaching technique. Since the aim of education no longer remains to be the mere acquisition of knowledge, the old technique has given place for newer techniques suited to achieve the newer objectives of education. Acquisition of knowledge no doubt, is important but it is only one aspect of the broad aim of education. Further, it is not an end in itself but only a means to another end, namely, the development of the whole personality of the child. There ~~are other~~ ^{are} number of items which go to develop the child's personality. Hence there ~~are a number of~~ ^{are} other items that compete with the acquisition of knowledge as outcomes of education. The application of the knowledge, the development of desirable attitudes and appreciations, ~~the development of desirable attitudes and appreciations,~~ the development of desirable habits and skills, the development of interests and the ability to tackle and solve problems in his effort to adjust to and control the environment-physical, social and natural - are all the objectives that go to develop the personality of the child. Some of them may be realised in the class-room by the instructional process; others may be developed by other means of education. The instructional process shall not consider that they are not its duties and responsibilities. No doubt, even those objectives which apparently seem to be beyond the class-room operation, are certainly linked with it. It is possible in addition, to teach those aspects of the subject while ensuring the development of other aspects of the objectives. So, the

method should be so designed as to assist the children not merely in the learning of the subject proper but also in the development of other important objectives of education. Though the method is mainly operating in the instructional sphere, it should bear in mind that we should adapt itself in such a way that the instructional outcomes contribute and strengthen the general objectives of education. Such a technique naturally takes into account not merely the nature of the subject but also the nature of the child. Further, it must be flexible to suit the differing nature, ability and needs of different children. Hence, any traditional method however best it may be, cannot be considered as the best one unless it is flexible to accommodate for the realisation of the broader objectives of education. In fact, the history of teaching technique is its progressive effort to extend its scope and flexibility with the expansion of the objectives of education.

There was a time when the nature of the learning process was not properly conceived by teachers and educators. It was thought that the mind of the child was like an empty pot and any thing could be poured into it. Naturally the method devised was simple. It was also thought that the child's mind was like a clean slate and that anything could be written on it. This concept of learning also demanded a simple technique for imparting that knowledge to the child, which the adults wanted. As a result of the above two dominant misconceptions of the learning process the teaching technique remained for a long time, crude and unscientific in its nature and narrow and dogmatic in scope. Today, the development in experimental psychology has thrown new light on the nature of the child and the way in which learning takes place. Among those aspects on which new light has been

thrown by studies in psychology, the following are important:

- I. 1. How learning takes place, and thought is completed;
2. Laws of learning,
3. The nature of the interests and how they develop;~~and~~
4. How attitudes and appreciations develop and
5. How habits and skills are developed.
- II. 1. How children differ in their ability to learn from age to age;
2. How their different interests try to mature at different periods in their growth and
3. How individuals differ among themselves in their ability to learn, in their interests and in their aptitudes.

The above contributions by experimental psychology have revolutionised the teaching technique. It is no more a crude, simple act of telling but a scientific, flexible and complicated technique of dealing with children, with the purpose of assisting them in their effort to develop their entire personality.

The third factor that controls the nature of the teaching technique is the subject matter. The method that suited for the teaching of literature or history may not suit the teaching of science. Even while teaching science the teaching of different topics may require different techniques. If lecture demonstration technique may be suited for ~~the~~ teaching a topic like osmosis, a heuristic approach may be essential for ~~the~~ teaching of the identification of the family to which a particular plant belongs. Similarly, the use of a film may be of better value than the ordinary lecture demonstration technique, for teaching topics of human physiology; and the project method may

be more suited to teach the life history of animals. Therefore it becomes evident that the normal technique of teaching may have to be adapted according to the nature of the topic.

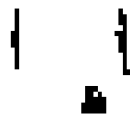
Time is also a factor that is to be taken into account while selecting a method of teaching. Particularly, if the teacher has to cover the portion prescribed for certain standard and if the pupils at the end of the course have to take up a public examination, the teacher will have to resort to telling or lecture method or lecture-demonstration method. If the examinations were to test the acquisition of knowledge or information, ^{the teacher will adopt a technique} certainly, that is advantageous both to the teacher and to the taught, from that particular point of view. But such a technique will not achieve some of the nobler objectives of science teaching. Yet that is the best method to satisfy the requirements of the examinations. This does not mean that such a technique of teaching science is to be followed by the science teachers. Rather, it is just to show how the time at our disposal controls to some extent, the selection of the teaching technique.

Lastly, the organisational and administrative facilities, the teacher enjoys, are also factors that go to influence the choice of teaching technique. The teacher, if he can command freedom with regard to the syllabus, ~~he~~ can rearrange it to facilitate his way of approach and his teaching technique. He can teach a topic like malarial mosquito by the project method if there is flexibility in the schedule of work. In the absence of such a flexibility and adequate freedom, he has to follow the lecture-demonstration method. If in the schedule of work, single periods of 40 or 45 minutes each, are provided for

science work, he can adopt the lecture-demonstration technique; where as he can follow the practical or the laboratory method if he can have continuous periods extending over 90 minutes or more. If the teacher were to have sufficient time for preparation before each lesson, he can arrange to demonstrate a good number of experiments; and if he does not have that facility he may have to leave off some of those experiments. Above all, if the teacher can have enough freedom he can try newer and newer techniques of teaching and evolve suitable techniques for teaching pupils in his classes.

By the foregoing it becomes clear that though ~~though~~ there are a good number of methods for teaching science, their selection and suitability depend upon various factors. Even after selecting a particular technique it may be required to adapt it to the particular topic. While teaching certain topics more than one method may have to be followed. Flexibility in the method helps the teacher to adapt it to the particular requirement. Freedom and skill on the part of the teacher help in the selection and adaptation of the technique in such a way as to achieve the desired goal at the minimum expenditure of time and energy.

As dealt with in the earlier chapters, there ~~are~~ a ~~good~~ number of methods which are usually considered in connection with the teaching of science. If the method of observation is suited to primary schools a more practical approach may be necessitated in the middle schools. A lecture-demonstration method may be popular in higher grades of instruction. This aspect clearly demonstrates the fact that at different grades of instruction different types of teaching



methods may have to be adopted. This is mainly because of the varying emphasis laid on the different aspects of the objectives of science instruction at different grades of instruction.

Since descriptions of the different traditional methods of teaching science are to be found in all the popular books on science teaching, I will restrict myself to some of the new features of the teaching techniques that are evolving in the field of science teaching.

The Concept of Learning Cycle and its Influence on the Teaching Technique:

The formation of concepts is preliminary to all kinds of learning. These concepts are stronger or weaker according to the way in which impressions are received. These concepts increase in meaning to the pupils as further impressions of the same sort but in an enlarging context, are received. This merely means that as learning progresses the concepts due to frequency of usage, become more and more significant and meaningful to the learner. This may be illustrated with flower as a topic of study. To the child in the primary school lower grades, the concept of flower may be something like a differentiated plant part with attractive whorls. In the next grade, the concept of flower may extend through the differentiated function of those parts. In the next grade, it develops to the realisation of flower as an organ to produce seeds for propagation of plant species. In this way the meaning of concepts will go on extending year after year. This provides the strengthening of the concept on the one hand and extension of understanding on the other.

The application of the above principle may suggest that the

subject or science may be taught with a concentric pattern of approach to the subject. Though this is a type of organisation of the subject-matter, the technique of teaching takes a new shape with this type of approach. Though the same topics are taught every year, they are treated in growing elaboration and detail. Therefore the method is such as to extend the horizon of the concept at different successive grades of instruction. This trend has influenced the organisation of the contents to suit its requirements. The general science course is commonly organised on this concentric line particularly, for the primary and lower secondary grades of instruction. This gives scope for repetition of similar situations which help the growth and scope of the concepts.

Sometimes it is stressed that the result of teaching must appear in the change produced in the personality of the pupil. This merely means that in science and other subjects, the knowledge learnt is not an end in itself. It should rather influence the life of the pupil. In schools and colleges facts, concepts and principles are taught by one or the other method. But the application of those aspects to life problems is frequently neglected. It is this deficiency that makes the technique ineffective. The problem solving technique which has been mentioned previously, has been evolved in the field of teaching science and other subjects just to complete the above deficiency. Such a technique has been called by John Dewey as a complete act of thought. The following steps of his technique may be mentioned here:¹

- a. Sensing the problem or difficulty;
- b. Analysis of the problem;
- c. Collecting evidence on the problem;
- d. Interpreting the evidence and
- e. Conclusion and application.

Though the above steps were invented for any act of thinking, they apply particularly well to the teaching and learning of science. Whether it is to develop in the pupils the functional understanding of facts, concepts or principles, ^{or} for the growth in their manipulatory ability, ^{or} for the growth in their ability and skill to tackle and solve a problem or for the development of their attitudes, interests and appreciations, the above procedure is quite suited. It is recognised as an effective approach to teaching and learning of science, both by the psychologists and by the science teachers. It provides for starting the lesson with an act of motivation; then we can develop the topic or demonstrate the experiment or direct the pupils to understand the facts or concepts or generalisations and finally ^{to} apply those things to their particular problems. It is the same as the inducto-deductive technique which is popular in the continental countries. It is the basis for the problem solving technique which is popular in America. The problem solving technique which is popular among the science teachers of America is nothing but the ordinary inductive with deductive technique or ~~xxxx~~ inducto-deductive technique. But the whole process takes the form of a purposeful effort on the part of the pupils to solve a felt problem. The purpose procures the pupils' motivation and contributes for the maintenance of continuous interest for the learning. As it is a learning meant to solve their felt problem, it becomes meaningful to them. The steps of the above technique are differently stated by different authors. One pattern of the steps is given below:

1. Exploring the unit;
2. Experience getting;
3. Organisation of learnings and
4. Application of learnings. 2

The above steps closely approximate to the steps of the scientific method. In the continent, the scientists simply state experiment, observation and inference as the steps of the method. When elaborated it takes the form of the problem solving technique.

Whether we use the above technique as the sole method of teaching or bring in problematic situations within the lesson, the technique makes learning effective. Hence it can be comfortably used as a simple but effective method in teaching science. Whether we teach by the lecture method, lecture-demonstration method, the laboratory method, text-book method, the individual method, the small group plan, the development plan or by any other method, it is possible to introduce the problem solving spirit and situations.

In England it is very difficult to give any traditional name to the technique employed for teaching science. One may wonder at this statement. But it is a fact. This is primarily, due to the teachers' unwillingness to conform to any set groove of the method. Secondly, it is due to the freedom enjoyed by the teachers which encourages ~~from~~ them to follow their own method. Naturally there is wide variety in the teaching method and approach to the subject. In the Grammar school the method of teaching that is commonly used is the lecture-demonstration method backed by laboratory work. Though they combine lecture demonstration with pupils' laboratory work in the early grades

they are separated in the higher grades particularly in the sixth form. In the lower classes the pupils will be provided with apparatus and appliances to experiment and find out for themselves. To some extent the Heuristic principle is held good even to-day. But the teacher will be there to assist the pupils. This is usually in the first half of the double period. In the second half, the teacher develops the topic. The pupils will be quite active because, the topic relates to the experiment that they conducted just then. They will ask questions on points which they could not understand. The teacher also asks questions as aids to develop the topic. He may even demonstrate the experiment. Teaching aids like the specimens, working models, charts and teacher's own diagrams and other visual aids will be used. The teacher will be exact in recording, observing and calculating. He guides pupils step by step, towards generalisation. Invariably he guides the pupils to apply the principle or generalisation to familiar problems of life. A very prominent feature of his technique will be the dictation of notes. Pupils also prepare their own notes. But the teacher's notes will be more exact and elaborate.

Lecture and laboratory work are separate in the sixth form. Pupils are well guided with regard to the purpose of the experiment, apparatus to be used, precautions to be taken, things to be observed and the way of arriving at the generalisation. Printed or typed instructional sheets will be supplied to all the pupils. They ^{work} ~~make~~ either in pairs or in singles. The practical records will be corrected by the teacher and the pupils are asked to follow the corrections.

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With regard to the lecture class in science for the sixth form the teachers invariably follow the college method. Demonstration of difficult experiments will be done in the classes. The simpler ones are reserved for pupils' own practical work. ~~Some teachers~~^{few} ~~are~~
~~reserved for~~ pupils' own practical work. Some teachers do dictate notes even at this stage. But in all ~~Grammar~~ schools pupils will be asked to read standard books in the subject. Rigour of the scientific method, wide reading and laboratory discipline are three things that attract our attention in the method of teaching science at this level.

Methods of Teaching in Modern Schools:

More interesting features in the method of teaching science are to be observed in Modern schools. Most of the pupils leave the school after the 15th year of age and think of settling down in life. Further, they are all pupils of moderate ability. Naturally science to them, is a subject that is expected to help them in their practical affairs of life or to do some job better. Naturally the method of instruction will be to assist them in their above aspiration. Neither the rigour of method nor the laboratory discipline are going to loom large in the technique employed to teach them.

The pupils of the modern school differ very widely in their ability to learn, ~~in~~ their interest and needs. Even in one class which is formed on the basis of their ability ~~there~~ will be pupils with differing needs and interests. Some of them ~~may~~ have interest only in certain aspect of the subject. Some of them may have the need to study only certain aspect of the subject. The method of teaching the

subject is so adjusted as to suit the varying ability, interests and needs of those pupils. Naturally such a method as to satisfy the above said differences, becomes individualistic in nature. Each pupil is ^{to be} separately attended ~~to~~. If pupils almost of similar interests or similar needs, are to be found they are grouped together for instructional purpose. In one of the schools, I visited, in Southern England five pupils in a class of 40 were interested in the working of a Radio receiving set. To them the teacher had started a project. They had to dismantle and assemble the parts. They expected to join a firm where that particular experience was needed. They did not study so much, of the other topics of science. The project extended over a number of periods. To a great extent the type of experience provided was mainly of a practical nature. The theoretical aspect of the work was taught to a slight extent while learning the radio-craft as and when necessitated. In another school in Midland a group of pupils were interested in joining a firm that was connected with electrical apparatus. They were given instruction in the different topics of electricity. The whole topic was to be treated in a practical way. Theory used to be taught to a slight extent. This combination of the minimum essentials of theoretical aspect with practical experience was the special feature of the technique.

Teaching
Science in the Secondary Technical Schools:

The teaching technique does not differ ^{so much} in the first and second forms ^{of secondary technical schools,} when pupils study general science as in other secondary schools. Lecture-demonstration backed by pupils' laboratory work is ordinarily

followed in the first two forms. The real difference in the way of approach appears in the remaining forms where science is invariably studied in the form of separate branches. Though the same lecture-demonstration technique, followed by a system of laboratory training, is continued in the upper forms also, the illustrations, applications, problems selected for solving, are usually from the field of the trade for which they are specialising. As one of the masters said the teaching technique in the Technical schools particularly in the upper forms, is such as to guide the pupils to have an insight into and to develop the ability of solving the problems in their particular field of vocation. This is because, every topic is taught in a technical setting.

Special Trends in the English Science Teaching:

1. Whether it is in the grammar school or in the modern or technical school the depth of treatment depends largely on the abilities of children. For example, one class might decompose water by calcium, magnesium and electrolysis, where as another ^{class} of less able children might use only electrolysis. Both the groups will realise that water is composed of oxygen and hydrogen. But the abler children would have had a more rigorous training. It is this flexibility of the technique that has enabled the schools to provide education according to their ability.

2. Activity forms the essence of English Science teaching; experiments form the basis for the development of the topic. The pupils in the laboratory will conduct all those experiments that are practicable

to them. The individual gets first hand experience of the knowledge by his own efforts in the laboratory. So far as the individual is considered this technique is without a substitute. It provides a very good intellectual training and develops the habit of following a scientific method whether they are engaged in the school laboratory or in their out-side activities.

3. Experiments for the pupils of the lower grades are generally set in the first half of the double periods. The pupils take to the experiment with a Heuristic spirit. The laboratory is pervaded by the real spirit of research. The teacher follows a technique quite suited to assist the 'Young Research Workers' in their effort. But the teachers are really liberal in their help and guidance to the pupils unlike the teachers who adopt a pure Heuristic technique. ~~The pupils~~ Before commencing the experiment the teacher does assist them to state their aim but does not give out the result of the experiment. Even those instruction sheets if supplied, will follow the same principle. The pupils are asked generally, to select their requirements from the store-room and they have to design how they are to be fitted to conduct the experiment. If they find any difficulty the teacher will certainly, assist but not until the pupil finds himself in that 'Cross-road' situation. Usually all those experiments that are to be conducted by the pupils are so designed by the teacher that they are suited to their ability. Hence, the pupils can carry on the work of their 'investigation or research' with confidence and with a good prospect of success too! No doubt, the teacher may demonstrate the experiment before they commence. But he will not demonstrate in full. He will only indicate the line on which the pupils will have to proceed

He knows that to divulge the result of the experiment robs the exercise most of its value and makes laboratory work a mere routine manipulation of apparatus. The science practical programme is no doubt, continuous with the theory work. There is no differentiation of the science course into practical and theory except in the top-classes. But the practical programme is so designed that qualitative experiments come earlier and quantitative later. This is just to procure the interests of pupils and also to cover the experiments in the limited time available. The course is thereby rendered suitable for the particular age group and their interests.

4. Science programme in the English and Scottish Schools does give prominence to demonstration lessons. Though individual experimental work has great value it consumes a good lot of time. Hence, if the schools were to stick on to that particular technique the scope of science programme will narrow down. So there is a scope for demonstration lessons also. Usually, the single periods are used for this purpose. The experiments for demonstration purpose will be very carefully planned. Generally, those experiments that are beyond the ability of the pupils are reserved for the teachers' demonstration purpose. The experiments generally set a high standard of technique with a very effective means of presenting the subject. Experiments that require costly apparatus or involve situations that are dangerous or those that require high mechanical and manipulatory skills will also be reserved for the teachers' demonstration table.

Usually the lectures in science for the secondary school children will not degenerate into mere talk. It should be suitably

illustrated. In addition, the lecture provides an opportunity for the pupils to acquaint themselves with the life and work of some of the outstanding scientists and ~~to~~ enables them to appreciate the role science is playing in revolutionising human ways of living.

The English science teachers lay equal emphasis both to their lecture-demonstrations and to the pupils' laboratory work. In fact, they have brought about a happy and profitable combination between the two.

The teaching of topics of biological science is specially interesting in English and Scottish schools. The depth of the topic is usually adjusted to the ability of the pupils. Seasonal variations the identification of species, naming of plants in the nearest locality, the study of the life history of insects, frog and other familiar animals, etc., almost take the form of short or long study projects. They also set up control experiments within the school laboratory and study the various aspects of animal and plant life. This is one of the ways in which control technique in the study of problems connected with life, is taught to the pupils. While teaching biology the teacher makes the pupils understand that the principles underlying the life of animals, also apply to that of man. Further, the principles, underlying the life of plants, are taught to the pupils bringing out their full implications for human life. Field trips and nature rambles are integral parts of the school programme in biological science. Visits to Zoos, birds sanctuary and museums will also form part of the programme.

Another feature that can be usually noticed in the teaching

technique, is an effort to study structure and functions together in the case of topics of biological science. No doubt, structure as such, ~~is~~ meaningless to the pupils. But when it is to be learnt by pupils it is not for itself but for understanding its function. The purpose of descriptive biology, particularly structural biology, is always taught in close relation to their functions.

While teaching topics of Physics or Chemistry the teachers usually apply principles or generalisations to immediate problems of life. As they proceed to the higher grades the application extends to farther environments of the child. While teaching, the teachers use actual specimens or appliances. They are supplemented by the teachers' diagrams and sketches. The special features of those drawings lie mainly in their accuracy and appropriateness. Many a time the teachers get pamphlets and other literature from the firms, factories, state departments or the community organisations that are connected, and make use of them as effective aids to teach. The teacher will also take the pupils to factories and other firms where the particular topic is applied to human affairs. The commonly used machines, instruments and other materials loom large in the ~~real life~~ fields of application, while applying the generalisations, formulated by the pupils.

Usually the English parents do not like that their children should be asked to do home work with regard to any subject. But, they will not object if the so called exercises set, take the form of activities. Making use of this attitude of the parents, the teachers set exercises that involve some activities which on the one hand, go to enrich pupils' knowledge of science, and on the other to encourage them

same time it helps to develop their oral ability in reporting. This helps to improve their language ability. Observing and recording are insisted by the teacher and particular attention is paid to accuracy and intellectual honesty in the laboratory work. This is said to contribute for the growth of discipline in the pupils and subsequently, for the development of their character and personality.

Some of the Activities undertaken to enrich Science Programme:

Activity forms the essence of the technique of teaching science both in England and in Scotland. In addition to pupils' laboratory work, a good number of activities, both inside and outside the school, form part of the science course. The pupils participate in the activities of the school science club. They take active part in building the school science museum which serves for the newer students both as a work of instruction and as a source of inspiration. Collecting science information from news papers and journals, either for the science club or for the science 'bulletin board' forms a very valuable programme to create interest in their mind, in the progress of science. During the school day celebration or the socials, an elaborate demonstration of experiments, their collected articles, specimens and other items of scientific interest will be undertaken. All these activities are carried out inside the school. In addition, many schools may maintain gardens and may rear some pet animals too. The school aquarium, vivarium and germination and budding sections will be interesting features of science activities. Every school may also provide opportunity to the children to get engaged in scientific hobbies of various types.

Among the activities that are arranged outside the school, visits to Zoos, birds sanctuary, sea-shore, hill-side, ~~trips~~, mines, ~~may be~~ factories, etc., may be mentioned. Pupils will also participate in Community Science Fairs and visit museums and birth places of great scientists. They are generally very carefully planned. They will have a system of follow up work also.

The above activities are to be considered as aids to teach science. They are planned in such a way as to enrich the science course on the one hand, and to strengthen classroom instruction on the other.

Some of the Familiar Aids used to strengthen Class Room Technique:

A ~~good number~~ ^{variety} of visual aids are prepared by the teachers themselves for their lessons. Those aids may be charts, diagrams, graphs, pictorial graphs, column diagrams, statistical representations or photographs. Illustrations are particularly used to make teaching more effective. Sometimes, they will be indispensable when the specimens cannot be procured. In English schools, film projectors are commonly used. Arrangements for darkening the science room will be invariably found. Film projectors are now available in the majority of secondary schools in various forms. The cinematograph projector is becoming more and more popular as it is more convenient to use.

In teaching topics of plant, animal or human physiology, it is very difficult to demonstrate the chemical or mechanical actions taking place in the organ. Films are prepared depicting a good number of such topics. Similarly films are manufactured on life history of animals.

Hence these teaching films can be used as very effective aids to teach a good number of topics in biology. But they do remember that the biology lesson should not degenerate into film-show. It is only the tool, though it contains some materials of instruction. It should be used very carefully and in suitable context. The English science teachers do not give so much importance to these educational films as in America. They feel that those films are merely aids or tools to teach and the main materials of instruction.

Another important aid that is frequently used, is science literature. In the market, one will find a good number of books written specially to suit the interests of school children. This scientific literature is only to strengthen classroom science. It covers a wide range of scientific knowledge and serves to stimulate and maintain pupils' interests as ^{it is} ~~they are~~ simple and attractive. Biographies of scientists are also made use of as a teaching aid. While dealing with the various topics of science the teachers draw the attention of pupils to the life and work of the particular scientist or scientists that contributed for the development of the topic. The pupils will be asked to read books on their lives and works. Simple books on the life and works of a good number of scientists are available in attractive form in the market. The pupils purchase them with great interest and read them both for knowledge, method and as a source of inspiration for service to mankind.

Conclusion:

By the foregoing, it becomes clear that the English schools introduce a spirit of research and investigation into the school science

programme. No doubt, that research is not of an original type but a sort of creative learning for the pupils. This reminds us of the once popular Heuristic technique of Professor Armstrong. In America teachers rather deplicate that it is foolish to place pupils in the position of discoverers. They rather, give to the science programme the colour of problem solving. It may be taught by the **project** method, assignment method, discussion method, laboratory or demonstration method; the work set to the pupils will take the form of solving a felt problem. No doubt, pupils are driven to the extent of feeling that life is a cluster of problems and every minute they have to solve those problems to live successfully in this world!. The statement of objectives of the lesson also takes the form of a problem. Science, no doubt, is a problem solving technique. But it is more than that. It is not merely a method but also a force, a culture, an attitude, an out-look, an intellectual adventure, a romance and a legacy from the past and a responsibility to the future! It is this human aspect that is important. In the English science programme we find that better justice is done to these aspects of the subject. The students by such an approach to the subject, not merely become methodical and practical workers but also good human beings.

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CHAPTER XIII.

SOME OF THE NEGLECTED OBJECTIVES OF SCIENCE EDUCATION.

Though the Philosophy of Science Education upholds the development of a good number of outcomes in the pupils as its objectives, the science programme is generally directed to realise not all of them, but only those that are usually measured by the examination at the end of the course. The traditional examination tests mostly pupils' ability to remember facts. Naturally the teacher sets a very high premium on the technique of memorisation of facts, principles and concepts. In addition to those objectives there are other more important and nobler outcomes of science instruction. Scientific attitudes, appreciations and the development of interests and skill in problem solving are some of these more important objectives of science teaching. It is not purely the defect of the teachers' teaching technique or the organisation of the science programme. Rather, it is the defect of the system of examination. If this system of examination is modified so as to measure the above outcomes of instruction also, certainly the teachers and administrators will re-orient the teaching technique and the science programme respectively, to meet the demands of the changed system of examination. The present essay type of examination can measure only the pupils' ability to remember facts and principles. Attempts are however being made to invent scales to measure the remaining outcomes also. A day will surely come when it will be possible and it will be necessary to measure those nobler outcomes of science instruction. The new type of objective tests under the modified system of examination, will



however be discussed in a subsequent chapter though they have yet to become popular. Meanwhile this chapter will be devoted to a consideration of those neglected objectives and the particular teaching methods that help us to develop them in the pupils.

1. The Development of Scientific Attitudes:

Recent investigations by several research workers have resulted in the formulation of lists of attitudes that are to be developed as a result of science teaching. One such analysis, based on the study of the Committees of the Colorado College of Education and the John Burrough's School, Clayton, has been reported in the Fortysixth Year Book of the N.S.S.E. According to the findings of the Committee the science programme should foster and develop the following attitude that go to modify the individual behaviour so that he may:¹

1. Look for the natural causes,
2. Be open minded towards work and opinion of others and informations related to his problems,
3. Base his opinions and conclusions on adequate evidences,
4. Evaluate techniques and procedures used and information obtained and
5. Be curious concerning the things he observes.

The above behaviours are really desirable ends of education. It is clear that they can be best developed as a result of instruction in science. This particular course of study has decided advantages over other school subjects to train the pupils through concrete and material evidences. Anybody can say that such behaviours should develop as habits in the life of the pupils. Development of any habit

requires rigorous and sufficient exercise in certain calculated activity. Therefore the above behaviours will develop in the pupils only when suitable activities are provided for in the science programme. Taylor's learning studies have revealed that how attitudes can be developed in the pupils. He says that attitudes are developed in the following ways:-²

1. When we assimilate assumption of the people around us or the points of view held by our friends certain attitudes are formed.
2. If certain circumstances were to bring about satisfying experience we develop an attitude favourable to that emotional aspect of the circumstances.
3. Certain experiences with deep emotional effect also produce certain attitudes of mind.
4. Certain objective attitudes are developed by an intellectual consideration of things, situations and circumstances.

The above ways in which our attitudes are formed will indicate the way of particular procedure to be adopted to develop scientific attitudes while teaching topics of science. Since consistency in the nature of the environment increases the possibility of forming attitudes we should lay emphasis on all those situations in the lesson that develop logical thinking, unbiassed assumption and careful recording and observing and cautiousness in judging, etc. While the class is going on, the pupils may be made to participate to feel the satisfaction arising out of their effort. Sufficient problems on the principles arrived at, may be set. The pupils may be asked to apply them to certain problems. This provides plenty of opportunity to the

pupils to understand how, at the intellectual level, there is scope only for scientific attitudes. These are some of the general principles we have to bear in mind while trying to develop scientific attitudes in the minds of the pupils. The science teacher should know what are all the desirable attitudes that the pupils should adopt and which of them are to be developed while teaching science. The various items that go to form the scientific attitude are listed in the previous pages. The list indicates that all of them are essential attitudes to be cherished by every individual of this scientific age. Whenever he gets certain situations he must make ~~the~~ ^{of} its full use ^{of} them. In ~~addition~~ to the teaching the pupils the contents, etc., he must also develop the particular behaviour pattern, ^{in the} which ultimately goes to develop scientific spirit. In a study conducted by Caldwell and Leuideen it has been shown that pupils between 12 and 15 have unfounded beliefs about the natural phenomena and that belief makes them behave in a certain pattern which cannot be naturally scientific.³

Certain studies conducted by Lichtenstein have revealed that direct teaching failed to produce change in the pupils attitudes at this stage. He suggests that out-of-school experiences and maturity of ideas are important in the development of attitudes.⁴ But his findings are opposed to the earlier findings made by Curtis. His study had revealed that direct teaching does modify the attitudes of young people.⁵

Widespread studies in this field have been conducted by Blair, Goodson and Vickland and others. Their studies have proved

that direct teaching does modify the attitude. Once again research studies have supported the findings of Curtis and others.

Therefore research field has probably yet to conduct a number of studies before it could come to any definite conclusion. Till then of course, we cannot sit quiet. The familiar and common sense methods of developing the same may be followed. Some of them are noted below:

1. Provision for Wide Reading:

The teacher may purchase a good number of books on general science suited to the particular age groups for the school science library or the school general library. He may maintain a list of those books with him. He may ask pupils now and then, to read those books. He may even assign those books to read and report. If those books were to include historical and biographical aspects they will make excellent reading material. Those situations do emphasise how the heroes of science worked and the particular attitudes that motivated them to do research work. Hence it is essential that in a course of science for general education, biographical and historical aspects of science must be included. If suitable reading materials are not available the teacher may devote some periods for inspirational talk on the lives and motives of great scientists. Such a type of science programme is commonly seen in the English Secondary Schools as well as in the Schools of many States in U.S.A.

2. Analysing Superstitions and unfounded Beliefs:

Many people in our country are victims of superstitions and other beliefs. Those beliefs and superstitions may be collected and

the pupils may be asked to analyse and explore their reliability. Children both at the primary and secondary levels show keen interest in the above survey and investigation. The pupils may be asked to personally study the effect of such superstitions and beliefs until they find out whether they are true or not. Though this work may look like a stunt it really helps to develop in them the scientific attitude which cannot be developed by mere talking about such attitudes.

Such superstitions and unfounded beliefs and traditions may be recalled while teaching related topics in science and, by material evidences, the pupils may be made to realise the fallacy of those beliefs. A continuous and frequent programme of this sort, builds and strengthens their scientific attitude or set of mind.

3. Laboratory Experiences to stimulate Scientific Attitude:

A sense of respect for the 'cause and effect' relation, underlies all aspects of realistic attitude. Such a realistic attitude paves the way for scientific attitude. The pupils while carrying on experiments or subjecting observations to laboratory control, will frequently come to realise that every action in this material world, is associated with a cause. From the beginning of an experiment to its completion the pupils have a good number of opportunities to exercise their mental process to develop the scientific attitudes. Particularly when the teacher insists upon certain amount of discipline in the laboratory work these opportunities will result in the effective development of the scientific attitudes. Clear statement

of problem, careful devising of the experiment, constant focussing of attention on the control and experimental factors, correct observation, precise recording, clear insight into the hypothesis, rigour of testing the hypothesis, cautiousness in generalising and universality in its application - are exercises that go to train the mind to set in the scientific attitude. The pupils must be trained to wait for sufficient evidences for basing their conclusions and to suspend judgment when they are not forthcoming. Added to these they must be made to think that their decision is only on the basis of the available evidences and that it is to change as fresh evidences may demand. It is this open-mindedness that is the entrance-gate for the successful operation of the scientific spirit and attitude.

4. Teacher's Influence and the Class-Room Atmosphere:

It is the conception of modern educators that the teacher should not try to influence the children by his personality. They think that such an attempt to impress his personality on the ~~part~~ pupils, retards the free development of their own personality in the direction designed by their innate tendencies. No doubt, there is plenty of truth in this statement. But can the teacher prevent himself from doing this even though he wants to prevent it? Moreover, even if he were to obtain^s from doing so what guarantee is there that the pupils will have better models on which they can develop? The superior and mature experience of the teacher may form the model which may help them to develop a good number of socially and individually desirable traits. Therefore, the educative practice while warning the teacher in his deliberate imposition of his personality on the

pupils, should certainly endorse his unconscious effort to assist by his examples and actions to set desirable standards for the pupils. This is more reasonable to expect in the case of developing certain behaviour patterns which are supposed to be the behaviour patterns that positively contribute for certain desirable ends. In fact, the greatest single factor that is responsible for the development of desirable attitudes, is the teacher who practices them day in and day out ~~after~~ in his class-room. Such a teacher in addition to his personal example, can also create an atmosphere in the class-room congenial to develop such attitudes in the pupils. He will create opportunities in the class for fearless and friendly questioning on the procedure, data, hypothesis and conclusion. He will also provide opportunities to the children to question the authority, both of himself and of the books. He will also prevent pupils going emotional in their discussion. Similarly, he will keep aloof from the minds of the pupils some of the prejudices and intolerances. He will also see that they clearly distinguish between facts and principles and maintain an open mind to revise their decision if need be.

Such an example of the teacher coupled with such an atmosphere, will go a long way in inculcating scientific attitudes of mind. That is why some teachers state that the test results obtained in a laboratory exercise is only minor where as their conforming to the laboratory discipline is the real outcome of instruction.

II. Developing Scientific Appreciations:

Appreciation is always associated with understanding. If I have to appreciate the accuracy with which the parental characters are

transmitted to the offspring it is essential to know the mechanism of heredity. Without such an equipment it will only be a blind adoration. Hence appreciation has to be developed in the pupils in close relation with the acquisition of their knowledge or understanding of scientific facts and principles. These basic experiences, essential for developing appreciations, cannot be developed in one period. This outcome of science instruction is a long range objective. But every successive experience will assist to enlarge and enhance the meaning and understanding of the appreciations. Though the development of appreciations has been an accepted objective of science education, it has not received the same attention of the teacher as the imparting of information or the ability to generalise and to ~~apply~~. This may be due to the fact that primarily, it is a long range goal and secondarily, it is usually considered to be the province of such curriculum areas as music, painting, literature and other fine arts. There is another reason also. Since it is a long range goal and is likely to develop as a logical conclusion of acquisition of knowledge, teachers may not evince sufficient and particular interest. Added to these reasons, the meaning of the term 'appreciation' is not usually made clear in the statement of goals. Above all, no examination will ask questions in science in that particular area. These are some of the ~~reasons~~ why 'appreciation' as an objective of science teaching has not received so much attention in the schools as it should receive.

One of the pioneering efforts to define 'Scientific Appreciation' was made by Alfred Nixon in an article entitled 'Meaning of appreciation' published in 'Science Education' in February, 1945.

He states that 'Appreciation, which involves both intellectual and emotional elements, is a sensitive awareness and preception of the importance or the utility of information in relation to other fields and in the development of attitudes and tastes'.⁶ Hence it becomes clear that all factual informations of utility and importance, form the bases for developing appreciation in children. These appreciations go to develop certain attitudes and tastes which have far-reaching consequences both on the fate of the individual and that of the nation.

Since Scientific appreciation results as a result of imparting informations, and as it is expected to evolve as the intelligent understanding of the importance and utility of those informations, expands in the mind of the pupils, the teachers may concentrate their attention to the imparting of the following types of information:

1. The life and work of scientists;
2. The methodology adopted by great scientists;
3. Contributions of science to promote health and to prevent diseases;
4. The gigantic nature of the work done by scientific machines;
5. The role science is playing in locating and solving some of the sociological problems;
6. The importance of conserving animal, plant and mineral resources;
7. Contributions of science to the raising of living standards and
8. The potentiality of science either to revolutionise or to destroy our civilisation.

Methods of Developing Appreciations:

The way in which we assist children to appreciate the importance and utility of science, depends upon the age of the pupils. This is in conformity with the earlier statements that the emphasis on the various objectives of science, varies from grade to grade, and subsequently, the method of teaching also differs in different grades. Those methods are to be based on the interests of the pupils and the objectives before us. The pupils at the primary school are interested in stories of imagination, adventure and romance. This interest will have to be utilised. Their interests may be so directed as to form a powerful motivating factor for studying science. There is a good lot of material both in nature and in the field of human discovery and inventions to keep up these interests. When the pupils reach the secondary school stage, their interests will shift from wonder, imagination and adventure to a more realistic approach to their nature, purpose and how they have evolved. They show a keen interest in the study of life of scientists, their motives, how they worked, the difficulties they met, the tact with which they conquered them, the method they followed, their success and failure, etc. Naturally our science programme should provide for all these experiences. It is possible to include them in a course of General Science. The study of the safety lamp, the discovery of the cause of anthrax, popular expeditions, firing the rocket to the moon, sending the dogs and apes to the inter planetary space, etc., are items that can be comfortably included in the course. In addition, all those landmarks in the history of science that have contributed for the evolution of human spirit, can be made as interesting as the above items and thus

can be made to serve ~~the~~ bases for developing pupils' appreciation in science and its role in human affairs.

The development of appreciation largely depends on the availability of suitably written books on science topics. Those books should be written in simple, clear and attractive language. The technical terms and technical situations may be limited to the unavoidable minimum. The treatment must be artistic enough never unscientific. Such books are published in large number in America. It may be interesting to note that the titles given to those books go a long way to attract the pupils' attention. The Story of the rock, Denizens of the forest, You and Environment, Life through Ages, Animal Friends, Plant friends, etc., are titles which create a desire to study and a suitable background for the development ^{of} appreciations.

In the top classes of the secondary schools topics of sociological importance and implications may be included for study. Such topics as ~~transportation~~ and communications, hydroelectric projects, irrigation works, river valley projects, atomic energy for peace, exploration of the interplanetary space, cross-breeding, conquest of diseases, etc., have plenty of scope for the development of appreciations in the minds of the pupils.

The development of appreciations through science instruction, will gradually result in the production of a new social order. The nation will evolve a new behaviour pattern at the aesthetic level. This change will certainly reflect both in our individual and social relations. It will also find its entry into the domain of art and literature. In one word, the creation of such a society, the

appreciation of which is developed on scientific lines will certainly keep the nation in harmony with the onward march of the industrial civilisation.

III. Development of Scientific Interests:

Interest is the mental disposition that is responsible for the mind to attend in certain particular direction. In other words, interests help the individual to attend in a particular way. That is why McDougal has said that interest is the attention at rest and attention is the interest in action. There are two main types of interests - Natural and Acquired. Pupils have a number of natural interests. These natural interests will be always trying to express themselves. Some activities will have to be provided for, to satisfy them. If those activities take the form of learning exercises we make the pupils learn at the minimum expenditure of energy. So the use of interest is always associated with the reduction of effort and subsequently economising learning. No doubt there will be secondary or acquired interests also. They will not provide economic situations for learning to start with. But such interests will gradually strengthen and begin to work as effectively and as economically as natural interests.

Many studies have been made to find out children's science interests. Trafton, Finley, Palmer, Downing and Zim are some of the important workers that have done some substantial work in the field. Their efforts have been responsible to undertake the organisation of science contents in accordance with the nature and maturity of pupils' interests.

If science interests are the bases for the organisation of science contents they are also the bases for evolving certain teaching techniques. For children whose interests are urging to express through activities, passive listening will be very difficult. This fact naturally controls the type of teaching technique we have to employ in teaching science at different age levels as indicated in the earlier pages.

While teaching any topic of science the teacher will have to bank upon the immediate interests of the pupils. If the contents and the way of approach are based ^{on} the interests of children they will attend to the learning. That is why in every lesson there will be introductory step to start with. This interest in action should be maintained throughout the lesson. It is likely that it will wane now and then. It is necessary, therefore, to think of levelling up those interests again. It is for this purpose that at the end of every thought unit, there will be a short introduction or transition to the next stage.

Interest is to be considered from another point of view here. In the above paragraphs it is mainly treated as a means to an end. It is also an end in itself. Pupils may develop deep and abiding interests in the subject of science. These interests may function on into their adult life. They may even be useful in their vocation or avocation in life.

The tendency to restrict the opportunity of pupils to study only one or two branches of science in the name of specialisation, is harmful. It prevents them from developing their natural interests.

P.P.Claxton, the Commissioner for Education, U.S.A., expressed this alarm as early as 1914, as that tendency was very strong everywhere in those days. So a course of general science is best suited for children to develop their interests.⁷

The following are some of the interests the pupils exhibit:

1. Interest in the study of heavens;
2. Interest in animal life;
3. Interest in gardening;
4. Interest in making things;
6. Interests in collecting rocks, minerals;
shells etc.;
7. Interest in birds;
8. Interest in the Chemistry of things and
9. Interest in Photography.

Pupils' interests in the above fields when fostered properly, will develop in the school days and continue to do so in their adult life. Some of the pupils may find it worthwhile to spend their leisure hours in those pursuits in which they are interested. Thus the science teachers will have to consider that development of such interests in the school not merely helps in their learning activity in the school days, but ^{also} ensures them a hobby to serve as ^{an} item for the worthy use of leisure.

These interests in the school days may also take the form of 'special bent' in one or the other fields of the subject. Such interests when properly provided for in the school days, will help the individual to specialise in that particular branch in the University. It is to satisfy such a type of science interest that the elective science courses are provided for. But pupils at the top classes of

the secondary schools frequently show a desire to study certain aspect of science which may be related to some vocation. They may have interest in topics that are closely related to some careers like engineering, medicine, agriculture, mining, transport, communication, etc. The educators, teachers and curriculum makers, while drafting the Science Programme, will have to take into consideration the nature and type of pupils' interests and try to provide adequate opportunities to foster them. In the case of vocational interests it may not be possible to cater to the particular type of career. But topics such as to assist in that particular career may find a place in the science curriculum.

With regard to the method particularly suited for developing pupils' interests it is very difficult to locate any definite method. We can only consider the general approach by which we can direct and foster pupils science interests. In this connection we may remember that the development of pupils' science interests does not mean that we must make the science class a place of mere entertainment; but it should be a place where the pupils should be tempted to throw themselves into worthy forms of activity. This provision must enable them gradually to ^{use and to} establish those interests in the school days, and ~~use the~~ develop them in the greater world, beyond the school.

The school science programme will have to provide for the demonstration of some of the experiments to activate and develop the inherent interests in the romantic and adventurous aspects of the subject. But these demonstrations shall not serve the transitory purpose of introducing some stunt elements into the class room procedure.

They will become really interesting and meaningful only when they are demonstrated as part of pupils' effort to solve their felt problem. It is in such a situation that the tendency of pupils to disclose their activity in ever-developing patterns or forms will find a worth-while outlet. Scientific informations, discoveries and inventions, skill in scientific craftsmanship, etc., have a strong appeal to pupils' interests. If these experiences were to be introduced while they are solving their felt problems they will be meaningful and even such as to enlist their admiration to the creative aspect of the human spirit that was responsible to build those cultural edifices. It is here that they can appreciate that all those contributions, that fall under the august names of Truth, Beauty and Goodness, have come to this world through the human effort.

Any method will have to make use of interests to start with as a tool to acquaint the pupils with the existing wealth of human achievement. This is the conservative aspect of the technique in developing interests. As experiences grow and organise into systems or patterns, the pupils' interests become more expressive, thus finding newer channels for their creative expression through activity. So the development of interests involves two faces. Firstly, those interests will be made the means to an end namely to acquaint the pupils with the wealth of science. Secondly, they will form themselves the end points and acquire the power of creative activity which may form the original contribution to human progress. In other words, the native interests of children which in their original nature expressed themselves in the crude movements of mind and body, gradually grow into creative activity. The technique employed should make use

of their interests first as means to an end and later on to develop those interests themselves as the end points.

Problem solving method certainly, can enlist a good number of interests of the pupils; it is because, that activity is a complex process involving a number of processes each one of which may depend on one or the other interests. The strength or the force of the purpose behind the project, renders additional impetus for those interests to get activated. Moreover, the various steps of that technique, namely, defining the problem, devising the experiments, recording, comparing the facts, postulating the hypothesis, testing the same and finally the conclusion - are all thrilling and adventurous in nature. Hence they contribute for the animated expression of the concerned interests. They also serve as exercises to extend their scope as a preparation on the part of pupils to shoulder their future responsibility.

With regard to the development of interests it is to be noted that many of them reach full development in the secondary schools and naturally the science programme should provide suitable facilities for their expression and further development. For fostering such interests the science clubs are suitable devices. Natural ~~///~~ History Societies are also of the same nature. In big schools separate clubs may be started to cater for the different types of science interests. Such clubs as Photographic club, Radio club, Horticultural club, Birds' migration club, Consumers' club, Forest conservation club, etc., may be organised. The activities of these clubs when properly organised and conducted, will go a long way in fostering the science interests of pupils.

Technique for Developing Problem-Solving Ability:

Another neglected aspect of the outcomes of science teaching is the ability to solve problems. The present society has become more complex than ever before^{and} as such the situations present problems at every step and demand their solution as a necessary part of one's duty if he has to live successfully in such a society. Since this complexity has been mostly due to the advent of science and technology it becomes evident that such a skill and ability should be developed as part of science instruction. This does not prohibit other subjects from doing it. Nor does it mean that they are exempted from discharging their responsibility in this field. It is only to say that it can be best done while teaching science, as pupils are likely to face in the society problems similar to those that are placed before them for solution in the science class. Added to this, there is an additional advantage of solving the problems with material evidences in science classes. That is why science is sometimes associated with problem-solving work. Hence it becomes essential that the school science programme will have to provide plenty of exercises to train the pupils in their ability and skill to solve problems.

Science provides ample opportunities for developing skill in the inductive and deductive lines of thinking. On the former line, the pupils will have to exercise their skill and ability in the art of drawing inferences on the basis of the collected evidences. On the latter line, they have to react in learning experiences that demand the application of the generalisation or the principle, found out, to solve some familiar problems or interpret, unique and new situations.

Moreover, in every lesson, though taught by any of the method, there will be scope for bringing in problematic situations that challenge pupils' ability and skill. Whether it is used as independent teaching technique or applied to part or parts of the lesson or to other activities connected with the school science programme, it should be remembered that the pupils will have to exercise their ^kskill and ability in many directions. It is this provision that serves as a programme for training them in their ability and skill to solve problems. It may be useful to elaborate here that technique and its different steps.

Steps of the Technique:

1. SETTING THE PROBLEM: The pupils develop skill and ability in problem solving only by actually participating in solving problems. The teacher will have to plan his instructional work for each lesson in such a way as to provide for the setting of some problems. The pupils participate with interest in the work, if those problems are worthwhile and arise out of their immediate environment. It is also essential to enlist their co-operation in stating the problem. The problem may be stated in such a way as to take the shape of a definite activity. The activity may take the form of exploration of a situation or reading a number of books to find the raw materials to start with. While stating the aim of a science lesson it may be stated in the form of a problem. This procures both the interest and the motivation of the pupils. Usually, the problem should be stated by the pupils. But the teacher should invariably assist the pupils to give a suitable shape to the problem. He must also see

that the problem is suited to their age and mental maturity. It must also be possible for the pupils to solve the problem ~~within~~ the available time and materials. Selection and statement of problem should enable the pupils to know what type of activities lies before them.

2. ANALYSIS OF THE PROBLEM: Statement of the problem should be followed by the teacher's acquainting the pupils with the method of solving the problem. Part of that method becomes the analysis of the problem. It may be analysed into one major and one or more minor keys. This is essential to enable the students to know ~~what~~ books they have to consult, what field trips they have to undertake, what experiments they have to set up or what experts they have to consult, to get the required information. Whether it is the major key or minor keys it must be clearly and crisply defined with suitable words.

3. COLLECTING EVIDENCES: It is at this level that the pupils acquire the real skill. They have to collect necessary materials from different types of sources. While exercising their skill in the different spheres of science informational sources they will not merely increase their experience but also sharpen and improve their skill and ability in collecting relevant information. They have to be careful in collecting only such information and materials which will help them to solve the problem before them. The teacher should inform them that they have to collect information to meet the differing and varying aspects of the problem.

4. INTERPRETING THE DATA: When once the relevant information

is collected, the pupils will have to be set to ponder over the same after organising the same in such a way as to make the underlying relation apparent. The pupils' reflective thinking commences here and this act is not a simple act but a complex act of many skills. The teacher may assist them through his well directed questions to break that complex into simpler ones, so that the pupils may be able to make reasonable interpretation of the data collected. This ability to interpret data may be analysed into the following specific abilities:

1. Ability to distinguish between facts and assumptions;
2. Ability to locate consistency or otherwise in data;
3. Ability to recognise the fundamental relations, underlying the data;
4. Ability to generalise the various types of apparent relations;
5. Ability to interpret the problem on the basis of the generalisation and
6. Ability to apply principles to new situations.

The above technique as stated already, can be used for teaching a good number of topics in any branch of science. Even though this particular name is not used, a good lesson does follow the steps of this technique, consciously or unconsciously. It provides plenty of opportunities for developing the pupils' skill and ability in solving the problems.

It is essential that the above outcomes of education which are usually neglected should be aimed at as worthwhile objectives of

science education. Mere imparting of information is only one aspect of the objectives of science teaching. The fact that, due to one or the other reason, the teachers concentrate on mere imparting of informations to the pupils, has made science a mechanical subject. When the above nobler objectives of science education are also insisted, the subject looks more human and commands greater prestige as it is intimately related to mankind and incessantly influences its ways of living.

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CHAPTER XIV

Designing and Equipping the School Science Rooms.

Whether it is in the primary or the secondary school the first essential for teaching science is the availability of adequate space. This demand is shared by few other subjects in the school curriculum. The fact, that there is no substitute in education for first hand experience, particularly so with regard to science education, makes the availability of space a logical necessity.¹ It is on this problem that the success of a school science programme depends as the best type of programme has to provide a good number of activities to the pupils. In addition to this a considerable amount of time in learning science is to be devoted for experimentation of one sort or another, and as such every school has to ensure while constructing, sufficient building space for the science block.

It is essential that science teachers should acquaint themselves with the type and area of accommodation required for their subject programme. Many a time the engineers and the educational officers approach the science teachers on the spot for details regarding the designing and equipping of science rooms.

Usually in every secondary school in India, there is a common general science programme for all the children. In addition, those who select science as an elective subject, will have to study separate science subjects like physics, chemistry, biology or botany or zoology etc. Therefore, it is essential, while building new schools, to design the general science laboratories as well as laboratories for

separate science subjects. Laboratories are to be differently designed and differently equipped for those different subjects. The problem commands greater attention both on the part of the teachers and administrators.

In all matters of educational organisation America has attempted to evolve objective principles after study and investigation. Therefore it may be interesting in this connection to know some of the basic principles that are set forth by the National Society for the study of Education in its Thirty First Year Book. A few of those principles that may be of help to us for designing and equipping science rooms are reproduced here:-

- (1) A science-room is one where pupils may receive educative experiences which add meanings to and give better understandings of those generalisations of science that contribute to enrichment of life;
- (2) Science-room experiences are justified from the science curriculum, courses of study and learning experiences to be expected of pupils;
- (3) A science-room is one where the experience of problem solving is also possible;
- (4) The plan and design of a science-room must provide elements of flexibility;
- (5) The design of both class-room and laboratory should provide for effective teachers' demonstration work;
- (6) Science room should provide facility for individual laboratory work.

- (7) There must be provision in the science rooms to provide certain facilities for objectification by means other than the use of concrete materials (Black Board, Bulletin Board, Display fixtures, Visual Aids, etc., etc.);
- (8) The planning of science rooms and their equipment should be a co-operative project in which the engineer, the educational supervisor and the science teacher, each, play a proper part.

The above principles indicate that the school science block must have both accommodation and facilities for the following aspects:

1. Teacher's demonstration work,
2. Pupils' individual practical work,
3. Space for keeping the necessary equipment both for pupils' individual work and for teacher's demonstration work,
4. Flexibility in equipping of laboratory and lecture demonstration hall so that they may be useful to different types of science courses.

Keeping the above facts in view we may try to consider the designing and equipping of the school science block.

For every school there is need for a science block consisting of a store room, lecture-demonstration hall and practical hall. For a long time science was taught in our secondary schools in the form of physics, chemistry and biology. In accordance with this differentiated nature of the subject, separate blocks ~~used to be~~ were

provided for the separate branches of science. In recent days, an integrated general science course is being introduced in all the secondary schools and that forms the minimum and compulsory science education for the secondary school pupils. The principles underlying the general science course, demand that it should be taught by one teacher, in one method and as one subject. We may also state that it should be studied in one room. Hence it becomes necessary to think of designing and equipping one common science block instead of separate science blocks for separate subjects, in each school.

The secondary schools which are now coming to shape in the new set up are designed to provide education for a period of four years after seven years of primary education. The upper classes of the secondary schools will have, in addition to general science, elective science courses. It may be a course in physics or chemistry or biology. Naturally for specialising in any branch of science there is need for special laboratories for the separate branches of science, which are going to be studied for specialisation.

As per the reorganised curriculum for the primary schools, science in its general form, is a subject to be studied right from the beginning to the end. Naturally we have to think of a science room for every school. Most of our schools do not have adequate building facility and nothing that could be called a science room. This is because of the fact that till ~~xx~~ very recently all schools had only nature study and science was not included in their curriculum. So, now, we have to consider the design and equipment of primary school science room also.

A Combined common Laboratory for General Science in Secondary Schools:

There is a growing tendency both in England and in America, to combine the theoretical and the practical aspects of the general science programme. In addition, a common laboratory is being used for general science programme instead of special separate laboratories. These two tendencies have led to the designing of a combined lecture-demonstration-laboratory hall to suit both the teacher's demonstration talk and the pupils' practical work. Such a plan will ensure not only economy but also an atmosphere of science in the demonstration hall. It also develops a sense of the unity of science in the pupils. Such a combined common science hall is particularly suited for smaller schools. Some of the designs of the combined lecture-demonstration-laboratory halls are described below:

1. The Combined lecture-demonstration - laboratory hall suggested by Dr. Whitehouse:

Any plan for the science laboratory, should be as economic as possible, particularly so in India. Keeping this fact in view Dr. Whitehouse suggested a plan for a combined lecture-demonstration - laboratory hall for the secondary schools of Punjab. It consists of a long hall, 25 feet wide and 45 feet long. At one end of the hall seating arrangement is to be made for forty pupils at dual tables. This is the lecture-demonstration section. At the other end of the room work-benches or tables are to be arranged to accommodate at least, 20 pupils for practical work.

The lecture-demonstration section can be used by the teacher for the whole class of 40, in its entirety, during his lecture-demonstration. During that period, the section of the hall intended for pupils' practical work, is to be kept vacant. During the practical hours, the hall can be used by about, 20 pupils for their practical work. During that time, the lecture-demonstration section is to be kept vacant. Though the hall can be used both for teachers' demonstration talk and for pupils' laboratory activities, only one section of it can be used at a time. But, the speciality about this plan is that a single room serves double purpose. In

addition, the breadth of the hall is reduced though the length is increased. Normally, to accommodate 40 pupils, a hall, 40 feet long and 30 ft. broad, will be required. It is costlier to construct a hall with a span of 30 feet than to construct a hall with a span of 25 feet.

The above type of science hall has become popular in Punjab and not in other States of India.

2. A Science Room to accommodate 20 or 25 pupils:

In a number of States in India regular provision for practical work in science is made only for those pupils who study science as an elective or optional subject. In the new set up, schools will have to allot only 3 or 4 periods per week for general science. Therefore, it may not be possible to think of separate practical work for science pupils, unless we can increase the number of periods per week. Even when we increase the number of periods, it may not be advisable to differentiate one from the other. But, we cannot teach science without making some provision for pupils' activity. So, we have to combine teacher's demonstration talk with pupils' activity. The science-room where the teacher gives his demonstration talk must also be suited for pupils' activity. While the pupils are active the teachers will have to attend every one of them individually. This is possible if the size of the class is reduced to 20 or 25. A convenient plan for a combined science room which can serve both as a lecture-demonstration hall and as a hall for pupils' own activities, is elaborated below:

A hall, 30 feet long and 25 feet broad, may be suited for this purpose. Two rows of dual tables, with six in each row, will accommodate 24 pupils. They can sit and attend to the teacher's demonstration talks. The tables will provide ample writing space. The space will also be adequate for pupils' practical work. A convenient size of the dual table is one of $3\frac{1}{2}$ feet long and $1\frac{1}{2}$ feet wide, with 2 feet high. The top of the table may be placed at a sufficient height, to permit the pupils' knees to be accommodated, while sitting. Suitable chairs may be used as seats for pupils to sit. Sinks may be provided at one corner of the hall. A teacher's demonstration table, 6 feet long and $2\frac{1}{2}$ feet high, may be provided. A wall cement-black-board of 10 feet long and 4 feet broad, may be provided. At

the other end of the room provision may be made for keeping germinating boxes, aquarium, museum, etc., on raised tables. Work space may be provided at the sides. Separate doors may be provided for entrance and exit. The hall may have an attached store-room (12' x 25'). This room may be partitioned so that half of it may serve the purpose of a preparation room. In bigger schools there may be another science hall of the above type on the other side of the store-room. Then, the store-room with the preparation apartment, will serve for both the halls.

3. A Combined Lecture-Demonstration - Laboratory Hall for 40 Pupils.

It is suggested above, that the size of the science class may be reduced to 25, so that individual attention and scope for activity for pupils may be possible; but it involves additional expenditure of a substantial nature. Hence, at least, till it becomes a possibility, we have to retain the class size as 40. Therefore, we have to think of a combined lecture-demonstration - laboratory plan for about 40 pupils, to provide both for teacher's demonstration talk and for pupils' own activities. Keeping the above requirements in view, the following plan is suggested for the purpose. This plan consists of a hall of 40 feet ^{long and 30 feet wide. The} teacher's demonstration table of the above description is in one end. Behind it, a cement concrete wall-black-board may be provided. In front, seating accommodation is to be made for 48 or 42 pupils at dual tables of the above description. They may be arranged in four rows, six in each row, or in three rows, seven in each row. The provision for sink, balance recosces, work space, aquarium, germination section, etc. may also be made. The dual tables may be equipped with gas and electric heads if the supply of the same is available in ^{the} locality. ^{Separate} doors may be provided for entrance and exit.

Construction:

Whatever the plan of the laboratory may be, certain common principles are to be observed while constructing the same. The floor must be smooth to facilitate easy washing and cleaning; seating accommodation may be arranged near the windows to ensure side lighting to the work-benches. If this is not possible, the work-benches, work spaces and the teacher's demonstration table may be illuminated from the top; windows and doors may open outside. The window cills may be used for keeping things. The windows may be fitted with window blinds to darken the room whenever necessary.

Furnishing:

There may be a space of 3 feet between the wall and the demonstration table. Raised platform for the demonstration table is not advisable and it is being avoided in all the progressive countries. The size of the demonstration table may be 6' x 2 $\frac{1}{2}$ '. The dual tables may be preferred to

dual benches as the top of the former is not inclined and provides greater writing space. Dual tables of $3\frac{1}{2}'$ x $1\frac{1}{2}'$ in dimension may be comfortably used.

If work benches are to be used, the benches of the common dimension, namely $6'$ x $3\frac{1}{2}'$ x $3'$ may be used. Each of them will accommodate four pupils. When the class size is bigger it may be necessary to group them in two or three to accommodate for activity, all at one time. It is however not convenient to use that hall for teacher's demonstration talks.

The science-rooms and science laboratories may be so constructed as to ensure a working space of 30 to 35 square feet for every pupil. It may be advisable not to provide sinks to the pupils' tables but to provide common sinks. A galvanised iron tank may be built at the top of the room to ensure water supply. Pipe will lead from it to the sinks.

Recesses may be built in walls for balances. The recesses may be one foot in width.

Six almirahs may be provided to store things. The size of the almirahs may be $7'$ x $5'$ with $1\frac{1}{2}'$ deep.

Separate Laboratories for Different Branches of Science:

In bigger schools particularly, for specialist students, it may be advantageous to plan for separate laboratories. Laboratories for physics, chemistry and biology may be separately designed. In addition to the equipment suggested for general laboratory, the physical science laboratory may have to be furnished with storage cabins, window benches, window cills, balance stands, etc. The chemistry laboratory will have to be furnished with

funehood with a blower system to remove poisonous gases from the funehood. If it is the biology laboratory, sections for aquarium, vivarium, germination etc., will have to be provided.

Stock Room: It is possible to have materials, apparatus and chemicals to be stored in the laboratory itself. Some schools in the west, both in the continent and in U.S.A., do store like this. But it is advisable to have a separate stock room adjoining the laboratory. By this we prevent the pupils from being tempted to meddle with the costly and dangerous substances in the laboratory. It will also prevent unnecessary loss by damage to the science section.

Where there are separate laboratories one for physics and another for chemistry, it is advisable to use physics laboratory for physics and biology practical classes and chemistry laboratory for chemistry practical classes only. Because physics laboratory easily yields for purpose of biology work and chemistry laboratory with its special fittings, furnishings and design is not so flexible. The latter must be at the side of the school building so that the ~~noxious~~ odorous and other smell may go away in the prevailing wind. If the school building has two floors the chemistry laboratory may be in the upper floor.

Preparation Room

There may be a preparation room attached to the laboratory or science room. If it is located between two laboratories or science rooms, it is possible to use it for two classes and at the same time, we may prevent teachers and pupils disturbing others. This is usually the case with science rooms in new buildings, built according to the

Ministry's regulations in U.K.

In the laboratory meant for pupils' biological work artificial lighting will be necessary for conducting dissection, microscope work, etc. A separate light may be provided to each of the dissection table. It may be so provided that it can be adjusted usefully even for observing specimens under microscope. The room may be illuminated with electric light so that while working at the table pupils' shadow shall not cover their table. A separate light may be fixed to illuminate the blackboard.

Adapting existing Laboratories and other Rooms:

In India, till now, most of the States had physics, chemistry and biology as three different aspects of general science in the secondary schools. The courses of study have been revised in all the states giving place for a general science course. The laboratory designed formerly for one or the other branch of science requires some alterations so that it may be used as a general laboratory.

While converting the special subject-laboratories, it must be remembered that the minimum common essentials both with regard to design and equipment, should be retained. As far as possible chemistry laboratory may be retained as such if there are more than one laboratories. Because it is not economic to convert a chemistry laboratory into a general laboratory. A good lot of unnecessary alteration have to be made and thus it involves heavy wastage. Side tables may be used alongside the walls to provide space for aquarium, vivarium and germination sections; lighting from above downwards on the work benches

may facilitate dissection and other biology work.

During the last decade there is an enormous increase in the enrolment in ^{the} secondary schools of India. But the extension of building facilities has not taken place on the same scale. So, a number of schools may not have laboratories. Some times class rooms or other rooms will have to be converted into laboratories. As this is unavoidable, we may remember the following principles while adapting class rooms for science rooms:

1. The rooms should be big enough to ensure both discipline and efficiency;
2. Sufficient light should be ensured. If that is not at all possible they can make the rooms brighter by using distemper or white wash. Artificial illumination may also be made;
3. Sufficient ventilation may be ensured;
4. Store-room, efficient drainage system should be provided;
5. A piped water supply will have to be made;
6. Other minimum essentials to ensure safety and healthy environment are also to be enforced.
The size of the room must be adequate to accommodate benches, cupboards and shelves and tables. There must be at least 25 or 30 square feet for each pupil in the class. A preparation room or space must be available in the room or in another room attached to it. It must be about 200 square feet atleast. There must be an adjoining room for storing if the laboratory does not have adequate space. The store must be atleast 16 feet ^{broad and} 12 feet ^{long.} ~~square feet~~. Each room should have more than one exit.

Adapting any class-room as a Demonstration-Lecture Room:

In many of the secondary schools in our country the strength of pupils ~~secondary~~ has far exceeded the capacity of the building. This is particularly true with the science block. As a result a number of classes in science will have to be held in ^{the} ~~same~~ periods. Naturally the teachers will have to carry all the apparatus and appliances to the above room. No doubt, ^{by} ~~turning~~ such rooms into science rooms ~~will certainly into science rooms~~ our pupils will be denied the laboratory facilities and the opportunity of doing adequate practical work. Yet it is unavoidable. As the problem is not very easy for the administrators to solve the teacher will have to show some patience and adaptability.

A tripod stand and a longer table may be kept in such rooms where frequently, science classes are to be held. The apparatus, chemicals and appliances required, may be carried in large trays. All the windows and doors may be generally kept open, facilitating easy escape in case of dangers. If there is a platform for the teacher it may be removed and replaced by a longer table.

Some of the necessities like water, sinks, electricity and gas connection (if available) may be made if a room is likely to be used for science class.

A 'Science Room' Programme for the Primary Schools of our Country:

Science is being introduced into our primary school curriculum only from a couple of years or so. The Basic Education scheme had included general science for pupils between 6+ to 13+ . But the

problem of having a laboratory for the purpose was not so much tackled in that connection. Therefore fresh efforts are to be made to design a suitable science room or laboratory for our primary schools. This does not mean that a hard and fast design should be invented to the schools of the entire country. It merely indicates the need for thinking of a suitable type of science room^{or} laboratory for our primary schools.

The number of primary schools is too high in every State to think of equipping our schools with science rooms as elaborately^{as} we notice in other countries. The cost of such a scheme will be prohibitive for us. Moreover, we have a good number of other problems to face in the field. Hence, the design and the nature of equipment should be such as to incur very little additional expenditure on this account. Most of the schools are located in the rural area where neither electricity nor gas supply is available. Even water is not supplied from a central town-water-supply system. Hence the design and equipment will have to be in accordance with the above environmental conditions. Further, the up-keep and maintenance of the same is equally a serious problem. The cost on that account also, must be kept at its lowest limit. Taking into consideration the above facts the following type of science room is suggested for our primary schools which give education to the boys and girls upto 13th or 14th year of age.

Many of our primary schools are single-teacher schools and the school buildings are of single-room type. In that open hall all the classes of the school (4,5,6,7 or 8 classes) have to ~~meet~~ and have their lessons. Naturally such a place cannot be used for science unless we

are prepared to divorce both demonstration and pupils' activity. Such a lesson in science reduces to telling and looks not much different from a history or geography lesson. It is under such circumstances that the old Nature Study was taught. That is one of the reasons why it became gradually a lifeless programme. So, we have to provide for teacher's demonstration and also for pupils' activities if at all the primary school science were to be of any use to the pupils. This necessitates the availability of space for the purpose. Even in bigger schools, usually there is insufficiency of accommodation because, the building was constructed for some pupils and their strength has of late, outgrown its original capacity. This expansion of education has not been followed in many schools, with suitable expansion of building. In a survey conducted by me in Nanjangud Taluk in Mysore State in 1943, out of every hundred schools fifty-six schools were working with insufficient accommodation. Funds were made available by the state to improve the position but usually, the work was not progressing as it was the responsibility of another department of the state (Department of Public Works). It was difficult to get suitable contractors in the rural area to undertake the work. As a result of all these difficulties the building programme did not progress. This is just to emphasise the need for extending accommodation facilities in our schools along with the rapid expansion of educational facilities. This aspect is elaborated because of the fact that the success or failure of the newly introduced course of general science at the primary school, depends upon the availability of space for pupils to be active and the teacher to demonstrate.

Therefore anybody can recognise the importance of providing science rooms to primary schools. This can claim top priority from all those leaders and educators who believe in the importance of beginning science education, right from the primary grades. A nation-wide campaign has to be started for adding a science room to our primary schools. They may be started by the central government and the state governments may follow the same. It is possible, a good number of philanthropic people will come forth to assist the state, in this programme. This programme will extend the accommodation facility in the primary schools in general, and procure increased support of the nation for science education, at that level.

The Design for the Primary School Science Room:

The introduction of science at the primary school level is only a recent venture every where. No country has yet specialised in designing suitable science rooms. In America pioneering efforts are however being made for the last thirty years. Craig, who is one of the outstanding authorities in the field of primary school science, published an article in 'Science Education' in May, 1930, entitled "The Place of the Science work-room in the Elementary School Programme". In this article Craig has listed the purposes which the science room shall serve. According to the list the science room should serve the purpose of:³

- 1) Providing an environment which will render a setting compatible with readiness for learning the elements set forth in the course of study in science;

- ii) Demonstrating the elements of learning set forth in the course of study and make them acceptable to the learner;
- iii) Providing for experiences which give exercise and drill for the elements of learning set forth in the course of study;
- iv) Giving opportunity for students' participation in constructing, assembling and caring for, and amplifying the materials of instruction; and
- v) Developing and maintaining the interests of pupils both in individual and group activities.

Since Craig was one of those responsible to overthrow Nature Study and introduce General Science into the elementary schools and was also responsible for laying the foundation of the courses of studies and teaching technique at that level, the above principles which he has listed deserve careful consideration. As per his list the room should be a platform for teaching science. The teacher will have to demonstrate his experiments to the class. The pupils also will have to do some work to enrich what they learn through other sources. They should also engage themselves in their hobbies that go to develop their interests. To provide for all these aspects the room must be sufficiently big and it should be suitably furnished and equipped.

The work-room for primary school should, on no account, be separated from lecture-demonstration room. Those two shall form part and parcel of the same science room. The size of the room has not been thought of in our country. Even in the western countries there is no accepted idea about the same. But in England the Upper classes of the Elementary Schools (11 to 14) had a science programme before

1944 where as the first six classes had only Nature Study as such no science room was planned for the early grades. We have to think of not one size for the whole of the country. Rather we have to consider the problem in relation to the size and strength of the school. In rural and smaller schools we have to be satisfied with a smaller room where, as we may require a bigger one for bigger and urban schools. For the first type of schools the size of the room may be 20 feet x 1~~2~~ feet with 6 to 8 feet in height. For bigger schools the size of the science room may be 20 feet x 15 feet or any other convenient size. This will accommodate ~~for~~ a class of 25 pupils or more. Since this breadth does not require roof support, the construction will be easy. The suggested size therefore, will also be quite economic. The room may be designed in the same way as elaborated for the secondary school science rooms. There may be ~~three~~ windows on either side of the room with one door communicating to the outside and the other to the main school building. If the room is at one side of the building separated by the wall, there may be 150 windows on the longer side (2) and ^{two} on the shorter sides (one ^{on} each). Smooth cement flooring is preferable as it permits easy cleaning. Due to one or the other reason if sufficient lighting is not available inside the room, illumination from the top may be provided.

Equipment: The heavy equipment recommended for Secondary schools is neither possible to provide nor will be reasonable to think of, for our primary schools. Because of the small size of the room, the furniture must be at its minimum essentials. There may be a ~~Table~~ Teacher's demonstration table of the same description as recommended

for the secondary school science rooms but the size may be of 6 feet x $2\frac{1}{2}$ feet with a height of $2\frac{1}{2}$ feet. Behind the table a board - either the fixed cement concrete wall-board or the wooden one, may be provided. There may be a sink at one end of the table connected by a tap, if water supply is available. If not at the right end a tripod stand with a basin may be kept or a glass or brass vessel with a closed top and a tap below, may be provided to ensure water whenever it is required. Below that tap a basin may be kept or a small sink with an opening to the outside may be constructed. Whereever there is electricity and gas the same may be connected to the demonstration table. Usually the former is available ~~for~~urban schools and rarely ~~for~~rural schools. Gas supply is not even found in our towns.

Dual tables may be used for pupils with raised seats. These tables must be broad enough to provide plenty of space for pupils to work. There may be two rows of five each. Each dual table is intended for two pupils. The size of the tables may be $3\frac{1}{2}$ feet x $1\frac{1}{2}$ feet x $1\frac{1}{2}$ feet. A common sink for the use of the pupils may be provided in one of the corners or two of the corners. There may be a table to keep an aquarium and some germination boxes, at the sides. Behind there may be space to keep almirahs to store things. Just before that, there may be space for 2 work tables where pupils may go and do some work of their interest (of course with the permission of the teacher!)

Both planning and equipment of the science room must ensure the provision for a well-rounded experience to the children. The pupils must have the experiences belonging to any branch of science

without any distinction. They must study plants, animals, air, light, machines, etc. Naturally the science room should have adequate equipment or apparatus and appliances and should be suited for different types of activities.

There are schools with a single class-room which cannot be extended in any direction. In such cases the above equipment may be provided and the teacher may teach science in the same room where he teaches the other subjects. This, of course, is the worst type of provision for science teaching. Yet we have no alternative. The only prospect is that in one way or other that school also will have some sort of science experience.

EQUIPMENT AND UPKEEP

It is part of the duties of the teachers of science to procure and to care for the materials and other equipment. Studies have shown that this aspect of science programme is not a very costly affair. But practice has shown that a good lot of funds are to be spent over equipping and maintaining the laboratory. But the department of education or the management of the institutions have always shown a tendency to question why that additional expenditure to science alone. No doubt, the progressive countries have realised that the fate of the country depends upon the type of laboratory equipment and maintenance. But yet the amount that is placed at the disposal of the science teacher in the majority of countries will be inadequate. Hence it becomes evident that the teacher should be very careful in spending that amount over materials of equipment. This requires proper planning in purchasing.

The teacher may refer to the syllabus or to the text-book and make a list of apparatus, appliances, specimens, etc., that are required for the teaching of the subject. Some text-books will furnish list of required articles and the total cost required for the purpose. If the funds available, may not permit the purchase of all the listed items, the teacher may give preference to the purchase of articles that are of need for demonstration work. The next priority may be given to those articles that are required for pupils' laboratory work. If funds are available the teacher may think of purchasing articles of permanent nature, like tools, and other equipment of a general nature. If after equipping once, special grants are made available, the general requirements of the laboratory may be purchased. The annual recurring grants may be utilised for upkeeping the laboratory.

The system of purchasing the articles of equipment and other materials for the laboratory differs in different countries. In some countries the schools are permitted to purchase from any dealers, certain minor requirements where as they are asked to purchase all costly and important materials from approved dealers after calling for quotation. Usually the lowest quotation is to be accepted. In doing so, no doubt, there will be competition among the suppliers and the cost of materials will be moderate. But there is the danger of lowering the quality of materials to encourage keen competition in rate. This is naturally not a sound system of purchase from the educational point of view. In England in some countries there are some approved firms where the teacher or the head-master may purchase the apparatus required for the laboratory. In such countries the

teacher or the headmaster with the assistance of the science teacher can actually go to the firm and make good selection. If the head-quarter firms are the only approved firms it will not be a convenient system so far as the rural schools are concerned. They may not find it easy to go over to the headquarters to make selection. Naturally they have to get the materials by ordering. This may not always ensure good quality materials. If unsuitable materials are received the returning of the same to the firm, will be a new problem. If the schools are allowed to purchase from the local dealers it is possible to select the best available with them. In some countries like U.S.A., some of the larger School Boards maintain a regular department for the purpose. All purchases to the school laboratory are centrally made. The department calls for the requirement from each of the schools and prepares a consolidated list of requirement and large scale purchase will be made. This system reduces the cost of materials. But this has its own disadvantages, too. Sometimes the particular type of articles or appliances as desired by the teacher may not be supplied. Even if the teacher were to mention it in his indent, while placing order for consolidated requirements by the central authority, the details may not be mentioned as such the teacher cannot be sure of getting the particular type of things he wants. Therefore it becomes clear that to ensure equipping^k the laboratory with suitable articles, other apparatus and appliances the teacher should have some freedom. The administrative authority may also retain some control in the form of placing centrally consolidated orders. Keeping^{in mind} these

modern principles of educational administration, the following scheme is suggested:

The Central Authority or the Director of Public Instruction may recognise a number of manufacturing firms, each for a certain item of supply only. While preparing the list of such firms the best firm in each of the fields should be selected. In this way a system of recognised or approved firms or companies may be completed so that most of the equipment for school laboratory may be purchased from those firms. Every school should be supplied with that list of approved firms. It must be made definite that those firms are for supplying only certain commodities. One firm may supply glassware; another may supply acids; a third one may supply wooden stands, dissection tables, boards and other tools; a fourth one may supply chemicals; a fifth one may supply specimens, so on and so forth. Schools may prepare their annual indents under the above heads and they may be permitted to purchase directly from those firms out of the funds allotted to that particular school for the particular purpose. This will ensure proper central control as well as freedom for the schools to get what exactly they want. Meanwhile the quality of supply also will be good.

An alternative scheme is to collect the indents from all schools in a district and ask the firm to supply consolidated requirements to the district educational officer who may supply the same to the schools as per the indents.

This may ensure certain conveniences at the purchase level but delay is invariably caused at the supply level.

In England there is a growing tendency to give more and more freedom to the schools to make their own purchases in any way they like provided the purchase is economical and the quality of materials does not fall short of the minimum standard. This has been necessitated because, for small incents of materials which may go short unexpectedly, the class teacher cannot think of following the long routine procedure to purchase. He cannot put off his laboratory work until he gets them through proper channel. Moreover, in every town there is a big heap of unused or damaged materials for sale. Many of them may be in good condition and available at a cheaper rate. Unless he has enough freedom he may not be able to purchase them for the laboratory. This particular situation has made it clear that the school should have greater freedom in purchasing the things for upkeeping the laboratory.

Other sources for Equipping the Laboratory:

In addition to the recognised firms for the supply of articles and equipment, there are other local stores from which the teacher will have to make purchases. Dine stores, hardware shops, fruit and vegetable market, local industrial concerns, local offices of Government, etc., may be of very important sources for the purchase of some requirements.⁴ It is possible to get things from local shops at a comparatively cheaper cost. Some of the locally prepared apparatus and appliances may be purchased if they are cheap and

good. For purpose of animal and plant study, animal and plant specimens are usually to be procured from the local sources. For immediate use many perishable articles are to be purchased from the local dealers. Therefore both for the convenience of getting the things and for the economy in the cost, the teacher may keep a list of such local sources of supply and try to purchase wherever there is immediate need.

Arrangement of Materials:

Storage of articles and other equipment should be carefully planned in every laboratory. There are different types of arrangements. The simplest type of arrangement is the alphabetical order. This type has no advantage of any sort except that the materials are arranged in the alphabetical order. Usually it has many disadvantages. Aluminium is to be placed with alkalies. Burettes are to be kept with bismuth; Iron is to be kept with imago. For an academician it looks as if the articles and appliances are clubbed in a disorderly manner. The other type of arrangement is to arrange or store the materials according to their nature. Glass materials are to be stored in one almirah, iron-ware in another, chemicals in another, so on and so forth. This is something better as it is based on the nature of things. This arrangement facilitates easy approach to things when they are in need. Another type of arrangement is to store things according to their classification. Metals, non-metals, Acids, Bases, Oxides, Hydroxides, Stands, Specimens, Bones, fossils, models, Charts, etc., are some of the sections in which we can arrange according to this type. This arrangement may be useful so

far as Chemistry is concerned. It may not of much use in arranging the apparatus and appliances meant for Physical Science Classes; So also with biology. Even with regards to Chemistry apparatus, there are better and more recent types of arrangements. In some of the laboratories they are stored according to the periodical tables so far as elements and their compounds are concerned. But this involves certain difficulties. Sulphur will have to be stored with Sulphuric Acid and Hydrochloric Acid with Hydrogen Peroxide. Some time such an arrangement will lead to confusion and accidents. But when we are doing lesson on Sulphur it is easy to get all the required compounds of sulphur. In biology it is usual to store things according to their nature. Models, Charts, dissection sets, preserved specimens, stuffed specimens, etc., may form such a groupings. Another more convenient and modern method is to arrange specimens, bones and charts in separate sections according to the phylum to which they belong.

A popular way of storing materials is to arrange them in the Store-room or laboratory in the order of their requirement for use in the demonstration class or for the pupils practical work. All articles, apparatus and appliances necessary for teaching that topic, are stored together. Things belonging to electricity are arranged in one place. Those connected with magnetism are stored in another almirah. This arrangement is found very helpful to the teacher to get the required materials easily.

In most of the Colleges of Technology ⁵ a novel type of arrangement could be observed in England. Tools, instruments, measuring

apparatus are usually arranged in order of their measuring capacity. Forceps are arranged in accordance to their size. Similarly electric meters are arranged in order of their capacity. This may be a convenient type of storing particularly in the Colleges of Technology. In schools the science departments may not have such tools and apparatus with such differing capacities.

Of the above types of arrangement every type has some advantages and some disadvantages. If an arrangement is suited to store materials, useful for teaching Physical Science, that arrangement may not be suited for other fields. So, it is better to resort to the arrangement of apparatus and appliances and other materials according to the area of experience to which they belong. Glass materials may be stored in one almirah, chemicals and reagents in another, acids in another. Ironwares may be stored in a separate almirah. Models, specimens and preserved specimens may be displayed in another almirah. Bones may be kept in another almirah. Fossils may be stored in a separate almirah. This arrangement is simple and facilitates easy access to things whenever they are required. Even for purpose of checking such an arrangement will be convenient.

Some schools in England store the materials in the Store-room. At the beginning of the year, all materials required for the year, will be stored in the laboratory desks. Every student is assigned to one of the desks and will be given the key of the desk. Each desk will have a card indicating (i) articles to be found in the various drawers; (ii) articles to be found in the cupboard of the

desk and (iii) articles which he can have access to on the side tables, ⁶ near the wall.

Such an arrangement is liked by the pupils. They feel they are sharing with the teacher in the responsibility of looking after the laboratory. These materials will be checked by the teacher at the end of the school year. If there is breakage, etc., the concerned pupil may be asked to make good. Such a type of arrangement may not be suitable to our schools. They may not be apparatus and appliances, sufficient for all pupils.

Whatever the arrangement of apparatus and appliances it may be, it must not lead to accidents. It must be easy to account and to find out what things and appliances are to be purchased.

Maintenance of Registers for the Laboratory Articles:

Whenever a laboratory is organised a stock register is to be opened. All articles and apparatus and appliances of a permanent nature must be taken to stock. In the register entries may be made under the following headings:

=====					
Sl.No.	Name of the Article.	Date of purchase.	Quantity	From whom purchased.	Cost
=====					

Another register may be maintained to note those articles of purchase which are of a perishable nature.

When once the laboratory is equipped the equipment cannot

last for ever. Fresh purchases are to be made every year. In the beginning of the year the teacher who is in charge of the science section, may prepare an inventory in which he can note down the articles, apparatus and appliances at hand and those that are to be purchased next year. This is to be done not on one day but as and when the teacher finds it necessary while making use of the laboratory. Whenever he finds that certain article is to be purchased for next year, he must note it in the annual indent register maintained for the purpose. With the help of this register the teacher can easily make a list of purchases to be made in the beginning of the school year.

The laboratory stock may be checked in the beginning of every year. This will ensure the deleting of things lost on the one hand, and acquainting of the things to be equipped or repaired for the coming year's work on the other.

Home-made Apparatus:

A modern science teacher is expected to know how to make some of the articles, apparatus and appliances required for his lessons. No doubt, such costly things, like microscope, telescope, camera, thermometers, voltmeters, etc., cannot be prepared by the teachers and they are to be purchased. Even if teachers were to try to construct them, they may not ensure accuracy and perfection, which characters are essential to those things. But, they can certainly prepare such things as models, charts, wooden stands, barometer, aquarium, vivarium, butterfly nest, etc. They may be prepared by the teacher with the cooperation of the pupils.



Many teachers of science show keen interest in improving a variety of equipments useful for science teaching. - A sample list of such improvised apparatus is indicated below:⁷

1. Electric Generator, improvised from an old car generator;
2. A rubber Balloon electroscope;
3. Bottles for collecting gas by improving olive oil bottles;
4. Pulleys;
5. Aquarium out of glass slabs and Wax and clips;
6. Ring Stands from iron rods;
7. Insect keeping boards from cigar boxes;
8. Toy telegraph sounder by bolts, wire and cigar boxes, etc., etc.

The use of home-made apparatus will ensure certain advantages for learning. The pupils feel that those apparatus and appliances are prepared by them and thus evince greater interest in learning. As they are prepared by them, they are familiar and thus make even a strange lesson a familiar experience. If the students participate in preparing them they will improve their mechanical and manipulatory skill which is one of the out-comes of science instruction. Some pupils may develop interest in making some of the material as a permanent hobby. In addition to these educational advantages the cost of maintaining the laboratory will also be economic.

Realising the above potentialities of using home-made apparatus special attention is being paid in the training institutions throughout England and Scotland to provide experience to science teachers in the laboratory art craft including glass bending, glass

welding, wood work, metal work, modelling and drawing, etc. This is made compulsory in some Teachers' training institutions though it does not form a subject for examination.⁸

To facilitate teachers and pupils to improvise some apparatus the teachers may be permitted to purchase out of laboratory grant, certain materials from shops or second-hand stores. There may be provision for purchasing necessary tools for the purpose; a work bench may be equipped in every school so that the teacher may make use of it in preparing his apparatus. The pupils may be asked to co-operate with the teacher, in preparing those aids.

A Recent Survey of Laboratory Equipment:

Though wars are usually considered as destructive events in the history of mankind, they are also events that generally contribute towards the human progress in certain fields. In fact wars were responsible for a good number of discoveries and inventions. The Second World War served as an impetus for the progress of science in many fields. Some of the discoveries like harnessing the energy of the atom, using penicillin and other fungi as wonder drugs for curing some of the diseases, the development of rocket as the fastest means of transport, etc., are some of the achievements of man during the second war. We also notice certain developments in the field of science education. All those countries that were directly involved in war operations had to face the brunt of modern weapons. Every individual had to participate in the defence and offence programmes. Those individuals who had developed certain discipline, served as better individuals, both in defending their country and in carrying on the

offensive to the enemy's land. This made the politicians realise that the modern wars are won not in the battle field, nor in the foot-ball field but in the school science laboratories! This realisation naturally led the Educationist and teachers to consider how best they could improve their laboratories. Attempts are being made in every country to study the position of their school laboratories and find out in what way they require improvement and extension. The same force has been responsible to realise the need for providing some sort of laboratory facility even for the primary schools if they were not already provided, since the majority of people will discontinue after that stage. It may be interesting in this connection to mention that in England, the Joint Committee formed by the representatives of the Science Masters' Association, Women Science Teachers' Association and the representatives of four Secondary School Associations, conducted a survey of secondary school science laboratories. In fact, the English secondary school laboratories are comparatively well-equipped and well-maintained. But yet, the Committee was not satisfied. There was need for improving the position, because the war had already demonstrated the importance of the school science laboratory. After considering the amenities provided for pupils practical experience in a large number of Grammar schools, the Committee published its report in 1958. In that report it is stated that 'the laboratories were on a dangerous instability of producing scientists and technologists in the near and distant future'. The Committee had every reason to express its alarm. The College and the University laboratories were well-equipped whereas the same attention was not paid to the laboratories of the secondary schools

and much less to those of the primary schools. The Universities which turn out scientists and technologists look to the secondary schools for suitable raw materials. The secondary schools naturally in their turn, look to the Primary schools. If the laboratories are well equipped and well maintained in the schools, certainly, those students who go to the Universities will have been better ground in the field. If the primary and secondary schools fail to provide suitable training in the skill and discipline of the subject of science before the pupils could go to University Departments, naturally, the production of scientists and technologists will be curtailed.

The Committee reviewing the position of laboratories has stated that the laboratories were -

1. Not enough in number ;
2. Not having enough members on the staff;
3. Not having enough laboratory assistants and
4. Not having enough apparatus.

According to the above investigation the schools were spending about £ 3/- for every boy in the laboratory. Only 44% of the schools had enough space for pupils' science activities.

The Committee also studied the particular problem of each of the schools with regard to laboratory facilities. The following is the list of problems they found:

1. No advanced laboratory;
2. Laboratory also used as form-room;
3. Over crowding of pupils;
4. Understaffing;

5. Science to be taught in other class-rooms;
6. 44% of the schools were permitted to purchase materials directly;
7. Other schools had to go to the County Supplying Companies and
8. Discount was important. Some times quality of an article was disregarded in favour of a higher discount.

The above problems are also our problems. Our Secondary school laboratories suffer from the very same difficulties in a more acute way. It is essential to set up a Committee to investigate into the matter, in every state and to suggest means and methods of improving the position.

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CHAPTER XV.

COMMUNITY RESOURCES AND SCIENCE TEACHING.

The common criticism against the education imparted in the schools through one or the other subject, is that it is divorced from life and does not connect the same with life. This of course is an important criticism since education is not an end in itself but for life. Such subjects like science which have developed as a result of experience in everyday life, and have in return, influenced everyday life, should be more particularly studied in close correlation with life. This principle is no doubt, accepted by every educator. But the gulf between education and life does exist as it existed before, because of the difficulty of teaching science beyond the four walls of the school. In recent days there is a tendency on the part of the curriculum makers to include a good number of activities to enrich the school science curriculum. These activities are no doubt, mainly intended to ^{provide the pupils with} ~~develop in the pupils~~ an opportunity to study things by first hand experience and to develop ^{their} ~~manipulatory~~ and mechanical skill. They will also facilitate to study the subject in close relation to the needs of the society and to understand the particular utility of things studied in the class room.

To bridge the gap that exists between education and life a number of new schemes in education have come to practice. Among them the community school is one. The principle underlying ~~in~~ this scheme, is that education should be imparted in a community setting so that education may become meaningful, real and related to life. Further, this also strengthens the new concept of education as life and for life

Though some of the schools follow this principle in full a good number of other schools also follow the underlying principle to a greater or smaller extent. This is made possible through two types of activities: 1. those activities of the community which are actually carried out with all the realism in the school itself, as in Dalton Plan or 2. the school tries to take the pupils to the community itself when particular topics are studied in that natural setting. In both cases pupils realise the inter-relatedness of their experience to life and develop realistic idea about the education they receive. The above two types of activities may be included in the science programme to enrich the existing curriculum and to correlate science to life.

The success of utilising the various community resources by the schools to enrich the curricular programme, depends greatly on the willingness of the community to provide such facilities. This willing co-operation may come, either as a voluntary effort or as a state legislative demand, from the community associations. In India at present there is no such legislative measure to facilitate. We have to depend upon the voluntary co-operation of a good number of community agencies. Another factor that is important in this connection is the flexibility in the school time-table.

A schedule of such activities to enrich and vitalise school science programme is listed below:

1. The Town water works:

This is a common community resource which exists in every important town. The pupils can be taken in convenient batches when

that particular topic is to be taught. Certain topics like Dynamo, pumps, purification of water, hard and soft water can be taught with concrete materials, on the spot, in their natural relation to community life. The teacher can guide the pupils in the preliminary introduction. The staff of the water works may help the pupils to understand the working of the plant.

2. The Museums.

Museums are usually to be found in big towns and as such, all schools cannot easily make use of this community resource. But it is possible to take the pupils once in a way, so that they may be able to study certain topics with concrete illustrations. If the museums organise special guidance programme the effectiveness of such visits will be comparatively ^{is} greater.

3. Public Parks and Botanical Gardens.

Parks and Botanical gardens are more frequent in towns and cities than the Museums. Usually the plants and trees are grown in distinct plots in accordance to the families to which they belong. ~~There are the~~ Hence study visits to ~~advantage of visiting~~ such gardens will be more purposeful. If there is a guide particularly to assist the students it is easy to study the various aspects of plant life and thus to enrich their class room experience.

4. Zoological Gardens

Though science deals with animal life it is very difficult to study in the class-room, the life of animals in a natural and concrete setting. In the Zoo, all types of animals are reared. They are housed in such a way as to provide the same type of ecological

conditions under which those animals can naturally live. It is hence possible for pupils to study the real habits of a good number of animals. Some of the rare animals can also be seen. Hence this community resource will be of great advantage to study certain topics of Zoology.

5. Factories.

The Science as a subject of immediate interest is exemplified in the role it plays in the industries. Though many topics of science find their application in any factory it is usual to select certain factory for studying certain particular topic. When properly planned and guided visits to factories can be of great use to make pupils appreciate the role science plays in the national economy.

6. Radio and Television.

In recent days Radio and Television are becoming very powerful agencies of general education. In some countries, regular school broadcasts are being arranged. Schools allocate certain periods for this purpose. In addition to making use of those services in the schools, the transmitting stations are also made use ^{of} by schools ^{as} places of great educative value. In addition to the actual work of broadcasting, ~~a large number of related~~ ^{many} topics of science are exemplified in the operation of the transmission station. A number of topics of science can be studied in this community resource.

7. State Departments of Public Utility.

Various state departments of Public Service like the Departments of Health, Food, Sanitation, Agriculture, Irrigation, Forest, etc., are established in every state to look after the public interest. These

branches are generally found in all important places. Every department tries to develop a technique of educating the public with posters, pamphlets, boards, folders, charts, diagrams, graphs and other attractive designs and illustrations. In doing so they demonstrate how they try to tackle problems of public interest in a scientific manner. They indirectly deal with a number of topics that are usually taught in the school science programme. But they are depicted in a more attractive and natural way. They are also dealt with in relation to life. Pupils find it more interesting to study the activities of a ~~good~~ number of departments. Hence it is advisable to make use of all those state departments for providing science education for the pupils.

If it is difficult to reach those offices and departments, arrangements may be made to get samples of their literature and other propoganda bulletins and use them as aids to teach related topics of science.

Similarly, a ~~good~~ number of community activities can be cited as sources for providing science education. Proper utilisation of resources to the advantage of the pupils can certainly enrich the school science programme. The State, the community resources and the institutions will have to co-operate in making the scheme a success.

As the impact of science on society increases, newer and newer resources will go on developing. The science teacher will have to acquaint the pupils with those aspects of the relation of science to society in one way or the other. The ~~best~~ way of doing that, is to take

the pupils to the particular community resource or centre and help them to study how that particular aspect of science is influencing human ways of living. This becomes, as days advance, an obligatory function of the school, if at all it can successfully educate the children to live in, and improve the nature of a community life. For realisation of this aspect of the objective of education there is need for flexibility on the part of the school organisation and willing co-operation to facilitate, on the part of the community.

The science teacher will have to make use of the educational potentialities of the above resources not in a sporadic way but in a planned and systematic way. Planning and systematisation of the above experience becomes possible only when those activities form part of the school science programme.

The teacher may plan to utilise the available community resource according to a prepared programme. This planning should ^{ensure} ~~be so done~~ that the period of visit to a particular community resource, synchronise with the time of studying the particular science topic, which is mainly illustrated in the community resource. The teacher may prepare such a plan in the beginning of the year. The plan may include the following aspects:

Sl. No.	Name of the Science topic.	Month in which it is to be studied.	Name of community resources to be utilised.
1			
2			
3			
4			
5			

CHAPTER XVI.

Evaluation of the Outcomes of Science Instruction.

Examination of one sort or the other has existed as an integral part of the educative process at all times. It is an attempt to assess the result of our efforts. But the criteria of appraising is changing from time to time. The method of appraisal also differs from time to time. Whenever we try to estimate the progress of every pupil we are measuring or examining. Too often our judgment in this field, may involve either measurement or estimation. What we can measure we measure. What we cannot ^{measure} we try to estimate. Many a time a combination of both, serves as a safer guide of assessing the worth of the result of our effort or the progress of a pupil or the efficiency of a teaching technique.

Educational practice involves planning and launching of procedures, appraising the results, shifting our attack and continuing to regulate our efforts in the light of the verdict of our evaluation. Though examination looks to be an isolated aspect of educational practice it is intimately related with the other operational procedures of the field of education. Hence it becomes clear that the purpose, technique and scope of evaluation depends on other factors of education. As the philosophy of education and consequently its objectives are changing from time to time the above features of the process of assessment also should change. As indicated in the earlier pages the philosophy of our curriculum has undergone a marvellous but very rapid change during the present century. Mastery of contents

was formerly the scope of the curricular philosophy and the consequential objectives of instruction. But to-day, the emphasis has shifted from the acquaintance with the three R^s, and the mastery of contents to the development of thinking, desirable attitudes and appreciations. Naturally the scheme of evaluation should no longer consider the measurement of mastery of contents as the only index of progress or achievement but should try to form an estimate of the outcomes of instruction in a pupil in other fields also, namely his ability to appreciate the true, the beautiful and the good on the one hand and the desirable attitudes he has developed, on the other. Every educator, administrator and teacher know how the former content-centred curriculum has shifted, during the last few decades, towards a life-centred curriculum. But our examination to a greater extent, is still sticking on to the old philosophy of education. No doubt, efforts are being made to revolutionise the purpose, scope and technique of the scheme of evaluation. But the results of the above efforts are yet to influence the body-politics of education in its practical procedure.

The new philosophy of the curriculum does not minimise the importance of the mastery of contents. Rather, it advocates that mastery of contents should serve only as the means and not the end. Whether it is literature, science or mathematics or any other curricular subjects pupils should study them not for themselves but for their relation to our life problems. So also the examination should try to measure not merely the factual information but also the ability of the pupils in making use of them to their life-needs.

All thinkers in the field of education realise the importance of the recent shift in the value we attach to the outcomes of instruction. But it is not so easy to measure the growth of the individual towards goals that are set on the basis of his life-needs and interests, as to measure his ability in the mastery of contents. Therefore our evaluation scheme will have to endeavour to measure both the above aspects of instructional outcomes. This task involves:

1. The construction of tests that can measure the mastery of facts and principles as well as the functional understanding of those concepts and generalisations;
2. To devise techniques to measure such elements as reflective thinking, attitudes, personal interests and social sensibility.

The Inadequacy of the present System of Evaluation:

As in other school subjects the achievement of pupils in science is generally assessed by the traditional written examination. This mainly reveals how a particular student reacts when a certain question is asked. But it does not measure how he reacts in real life situation. So, for evaluating the growth of his complete personality, we have to think of other devices to measure those that could not be measured by our written examination. The traditional essay type of questions, in the examination, intended to measure only those limited aspects, may not measure even that satisfactorily. In addition, it is a well known fact that such a type of evaluation is defective both in its device and in its result. It is to avoid these defects, the new objective types of questions have been evolved.

Even these objective tests are inadequate to measure all

aspects of the outcome of science teaching. So, whether we use traditional essay type of questions for evaluation or the new type of objective tests, other devices are ^{also} to be employed. Usually we have to analyse the work of the pupil with regard to his management of the experiment he conducts, notes he prepares, collections he makes, and the part he plays in the proceedings of the science club, etc. We have to evaluate his ability as indicated in his class-room questioning and participating in discussion. His behaviour in the laboratory work or class-room activities is also to be assessed. Such a combination of devices to evaluate the outcomes of science instruction, will be a measure of pupils' all-round development. ~~Further,~~ if the devices are objective, reliable and valid certainly the system of evaluation will give a correct and full estimate of the pupils' worth.

The construction and standardisation of the new type tests to measure the above aspects of science education were hampered because of the conflicting approaches to the outcomes of instruction till the publication of the 31st Year Book of Education in America. The Science Masters' Association in England also tried to crystallise the confused trends in the objectives to be realised by science teaching. Now both in America and in England tests are standardised to measure the different aspects of the outcomes of science instruction. Similarly, efforts are also in progress in India.

General Approach to the Evaluation Scheme:

The attempt to find whether a pupil has become more co-operative, self reliant or more reasonable in his behaviour, is certainly

a bold effort on the part of the educators. Though those qualities cannot be adequately represented by any percentage, it has become possible for us to estimate by the technique whether there is improvement or not. Attempts are being made to overcome this difficulty by dividing each quality into a number of constituent items. To measure the quality of responsibility, it is usual to measure its different aspects namely, willingness to fulfil his obligation, ability to fulfil the same etc. Similarly with regards to other qualities. Even while estimating on this line it may be useful to assess not once, but at different stages of the pupils' progress. This attempt to evaluate pupils' progress in science after analysing the different qualities or outcomes of instruction into different elements and into different stages, ^{has enabled us to measure those outcomes also. But} it is difficult to say that the verdict will be as objective as it is with regard to the evaluation of factual informations. But, there are certain qualities which can be assessed objectively to some extent. The degree of manipulative skill can be evaluated by practical tests. The degree of critical thinking can also be evaluated by suitably designed new type tests. Samples of different objective tests will be illustrated later in this chapter.

Purpose of Evaluation:

Whether the assessment is made through the traditional essay type of questions or through the new objective type of tests it is primarily to assess the pupils' progress in the subject. It also discloses the effectiveness of the teacher's work. The objective types are so designed as to measure whether the performance of a

class is equal to that of a similar group, or different. This indicates some thing about the teaching technique employed by the teacher. So we get a clue to know whether his technique of teaching is good or bad. Naturally the evaluation helps the teacher to improve his technique.

In addition to the assessment of pupils' progress in the subject, testing helps the teacher to diagnose the particular weakness of pupils and undertake suitable remedial programme as indicated in an earlier chapter.

They are also useful to assess the particular interests of children and thus to provide suitable science activities to serve the purpose of hobbies. Tests are administered for guiding pupils at the secondary school level for taking up courses of studies for which they have aptitudes. The department of Education at the University of Edinburgh have standardised such tests for guidance programme. Science tests are usually administered at 14 to guide the pupils to take up vocational courses. It is learnt that the correlation between achievement in science and success in vocational or technical studies is as high as 0.64. These tests are used regularly in Scotland and here and there in England. In America, Science tests are frequently used while providing vocational guidance to pupils.

While teaching the pupils, questions can be administered to find out whether a particular student is following the lesson or not. They can also be administered as aids to guide pupils from stage to stage while the lesson is progressing.

Evaluation, A continuous Process:

It is usual to think of evaluation as the end point of a course of study. But it is to be considered as part and parcel of any educative process. It commences from the beginning of the course and operates through out the course and finally to its end. The final evaluation, whether external or internal, may serve the total assessment of the progress of the pupil in science. But the periodical evaluation, which takes the form of various tests and questions, not merely helps to assess the periodical progress of the children but also helps ~~to assess the progress~~ as guides or aids or devices to the teacher, to adjust his work to the circumstances, so as to guide the pupils to the desired goal.

In every class the teacher asks questions with the idea of recalling to the mind of the pupils their previous experiences or to make certain point or situation clear or certain attitudes and appreciations more impressive and effective. He may also use questions to assess at the end of the class to know what essentials of the topic the pupils have acquainted with.

Periodical tests may be held two or three times in a year to take stock of the progress of pupils. In England class tests are conducted in science once in a term. They serve the purpose of estimating pupils' progress in science and also to locate their particular difficulties. But the former is considered to be more important. Usually essay type of questions are included in the test. Short answer questions are also included. The use of new type tests in

Secondary Schools is not as popular as they are in America. Usually 1/5th of the paper will include such short answer questions.

Annual examinations through a written ^{test} ~~examination~~ is commonly held all over the world. Usually in Science the practical aspect will not be tested. But certain amount of credits, given to pupils' practical work as measured by the evaluation of their records, will be taken into consideration while declaring promotions to the higher class.

In England at the end of the Secondary School the pupils take up Public Examinations. The questions set in science paper are mostly essay type of traditional questions. There is lack of a tendency to include new type tests in the scheme of examinations.

So in every institution evaluation has to be done from the beginning of the pupils' educational career to the end of the instructional course. The traditional scheme of evaluation also did include the periodical assessment of pupils' progress in their acquisition of factual information. In accordance with the changed philosophy of science education it is necessary to maintain a periodical assessment of pupils' progress in science not merely with regard to factual information but also with regard to their progress in other aspects of the instructional outcome.

Method of Assessment:

Written examination is the usual method of assessing the ability to know factual knowledge.

It is usual to give importance, while assessing, to the actual work done during the period of the study. Therefore every pupils' work must be assessed under the following headings:

1. whether the pupil's work is accurate;
2. whether the pupil has set out logically;
3. whether neatness is ensured and
4. whether adequate experience is gained.

Whatever procedure we may adopt to assess the actual value of work done during the year, the work must be analysed into the above aspects and each item valued separately. The total may be considered as the estimate of the pupil's work. This analysis is particularly useful while valuing pupil's practical records, work books, etc. If it is a question of evaluating the pupil's practical work, particularly his skill in carrying experiments, it is necessary to maintain a system of periodical evaluation of pupil's experiments. The average of these valuations may give the consistent measure of his skill in the laboratory art craft.

While estimating^a pupils' total work done in the year both his practical records and the degree of skill he exhibited in carrying out experiments may be taken into account.

Evaluation of pupils' work in the Class-Room:

While forming the final estimate of the pupils' work in the course, it is felt necessary to take into account the way in which they participated in the class room to gain science experiences. There are very many occasions to evaluate pupils' participation in

the class. Among them questioning as a device to teach will indicate pupils ability to participate. In science classes usually three types of questions participate. They are (a) Questions seeking information.; (b) Questions disclosing meaning and encouraging thought (c) Questions leading pupils to find out for themselves. If the teacher maintains a rough estimate of every pupil's participation in the class-room experience he can grade them according to their ability to answer the above types of questions. The first type of questions requires simple recollection; the second type of questions requires reasoning ability and the third type requires critical thinking leading on to investigation and generalisation. It is possible for the teacher, to have a rough estimate as to which of the above three grades each pupil belongs.

As it is in practice, short written answers may also be encouraged in the class-room. Pupils after answering may exchange their papers and try to evaluate the work. This may take the form of class tests which may be held once or twice in every term.

Pupils often ask questions in the science class. The nature of the questions they ask, often disclose the type of work they are doing and their mental make-up. No doubt, it is possible to understand by the above means which pupils are genuinely dull, which pupils are uninterested, which pupils are slow learners and which pupils are finding some slight difficulties here and there. Naturally an insight into the nature of these questions will help the teacher to adapt his teaching technique, but at the same time it helps him to have an estimate as to what category each pupil belongs.

The quality of a pupil is often shown more by his ability to ask a question than ⁱⁿ his ability to answer a question. The genius of a scientist lies in the selection of right question to ask ~~in~~ in the pursuit of the answers.

The informal and non-regimented arrangement of the science programme permits to turn the class into a discussion group. The teacher then assumes the position of the chairman. The pupils will participate in the discussion and exhibit their factual knowledge, mechanical skill (if demonstrations are arranged), critical thinking, scientific interests and attitudes and even appreciations. Since the pupils will be free to act it is possible for the teacher to have a correct estimate of ~~each~~ pupil's worth. Similarly, while providing guidance to the pupils in their practical work, he will be speaking to them individually and hence, it will be possible to study the interests and attitudes of pupils. If the teacher were to maintain a record for every pupil and were to note in it his opinion regarding the progress of the pupil in the different aspects of science achievement it is possible to have a more realistic estimate ~~of~~ of the pupils at the end.

Evaluation of General Progress in Science:

In an examination that is intended to evaluate the general progress of pupils in science, it is obvious that we should include all those types of questions that test the different aspects of the general outcomes of science instruction. Questions of the essay type may be included to assess the development of attitudes and interests

of pupils to some extent. Questions like "What are the claims of science to be a subject of study?", "Is science part of human culture and how?", "Who is your favourite scientist?", etc. will extract some answers from the pupils in which their feeling aspect will dominate. Therefore it is possible to evaluate by this means the development of interests and attitudes in them. But special tests invented for the above purpose will be elaborated later. In the majority of countries the essay type of examination continues even ~~now~~ to-day and it will continue to be so even in future. But that alone shall not form the result. We must take into consideration certain other aspects of the pupils participation in the science programme. Among them the following aspects, may also be evaluated:

1. Pupil's willingness to attend the science class;
2. Pupil's own estimate as to what type of experience was provided to him; and
3. An estimate of the pupil as a result of his participating ~~with~~ such science programmes, as assisting in experimenting, keeping shelves and cupboards tidy, renewing labels and keeping apparatus clean and in good condition.

So, while judging the general progress of pupils it is essential to take into account the above aspects also.

New Type Written Tests:

Among the written tests we have two types - short answer type and long answer type. The former are almost like the psychological tests where as the latter are the traditional type of questions requiring longer or shorter essay type of answers.

Short answer questions usually require minimum of writing and the time of the pupil is saved. They are of different types and the following types of tests are commonly used for evaluating science programme:-

(1) Logical Selection type:

Examples:

- A list of names of things or events or concepts, etc., may be given in which there may be one that does not belong to the same group as others. Pupils may be asked to cross out that word. In each one word is unrelated to the series. In (1) animals except Frog belong to mammals so it is to be crossed out. Similarly in others. This test helps to gauge the pupils' ability to analyse the problem and suggest that hypothesis which eliminates all but one.
- | |
|---|
| (1) Dog, monkey, Cat, Horse, Frog, Camel, Tiger. |
| (2) Centimetres, inches, metres, foot, ounce, furlong, etc. |
| (3) Wavelength, Frequency, density amplitude. |
| (4) Mars, earth, Saturn, Moon, Plato, Urenus. |

(2) Multiple Choice Type:

Examples:

- This test provides choice of several possible answers of which only one is correct. The pupils have to underline the correct one.
- | | |
|---|--|
| 1. Darwin lived in: | a)Seventeenth Century A.D. |
| | b) <u>19th Century A.D.</u> |
| | c)20th Century A.D. |
| | d)2nd Century B.C. |
| 2. Photosynthesis takes place in Seeds, Roots, Root-hairs, <u>leaves</u> , Pollen-graphs. | |
| 3. The speed of light ~~is~~ per second is: | 100 miles, 1,86,000 miles, 1,40,000 miles, 2,80,000 miles. |

(3) Sense discrimination Type:

Examples:

- The above exemplified multiple choice test is modified in such a way as to require the pupil to select such word or words that make when combined a logical statement. The pupils will have to cross out, those word or words and retain the logical form of the sentence.
- | |
|--|
| 1. Acids turn Blue/Red litmus Blue/Red. |
| 2. Flower is the organ of Respiration/Re-production in Angiosperms/ <u>Gymnosperms</u> . |

Examples (Contd.)

- (3) Chemilion is known for its Colour change/Tameness, for self-protection/Earning the Good-will.

(4) Matching type of Tests: Examples:

Two columns of words are usually given and the pupils are asked to match the items of the first with corresponding items of the second.

(1) Photo	-	Protin
(2) Butter	-	Starch
(3) Meat	-	Sugar
(4) Vegetable	-	Fat
(5) Beet-root	-	Salt

(5) Reasoning type of tests: Examples:

This suggests a variety of possible answers to a question. The pupils will have to select the most reasonable one. The test measures pupils' ability to reason out things and events.

(1) Plants in shade cannot form starch because
i. There is no heat
ii. There is no light
iii. There is no water
iv. There is no chlorophyll.

(6) True or False Type of Tests: Examples:

Three types of tests can be used to test the ability to remember certain experiences which they have acquired.

1. As we go higher and higher the pressure of air becomes less and less (T) and (F)
2. The roots are organs of plants (T) and (F)
3. Light travels faster than sound (T) and (F)

(7) Completion Type of Tests: Examples:

A word or words are left out from the statements given. The pupils are asked to complete the same.

1. The common name for sodium chloride is....
2. The organ that separates thorax from abdomen is.....
3. The transport that is used for interplanetary space travel is known as.....

It is always better to include all the above types of tests wherever we try to measure the general progress of pupils in science

since each one of them is intended to measure one or the other aspects of the outcomes of science instruction. If standardised tests are available the teacher can use them for the purpose. If they cannot be had he can construct his own tests and use ^{them} for the purpose.

Long Answer Questions:

Short answer tests are useful to evaluate the pupils' reasoning ability and factual knowledge. Certain other skills which the science course has to develop can be measured by long answer tests. Precise use of words, concise and accurate paragraphs, logical argumentation and sense of sequence of operations involved are usually to be evaluated by long answer tests. Long answer tests are as useful in evaluation as short answer tests. A well designed examination paper will include both short and long answer questions. A happy proportion of the two may be maintained in the question paper. Essay type of questions are quite common and hence no special illustrative questions are given here. But since it is considered that the evaluation scheme must try to measure the functional growth of understanding and not mere storing up of informations, attempts are being made to include special type of questions which are very different from the traditional essay type of questions. Hence some samples of such questions are given below:¹

DEMONSTRATION: A flask is filled with H.C.L. vapour by displacement of air in the usual way. A single hole stopper is arranged with a glass tube extending into the flask and with a rubber tube attached which

extends a short distance outside the flask. The rubber tube should be provided with a pinch clamp or it may be closed or opened with one pinching of the fingers. As soon as the flask is filled with vapour the stopper with tube is inserted, the flask is inverted, and the closed end of the rubber tube is placed under water in a beaker. When the end of the tube is opened the water rises into the flask to make a fountain. If a blue litmus solution is put in the lower beaker the fountain becomes red.

Questions to be Answered by Pupils:

1. If the flask was full of H.C.L. vapour what caused the water to start to rise in the tube?
2. As the first few drops of water entered the flask what happened?
3. Why did not the fountain continue indefinitely as long as there was water in the beaker?
4. Where should the end of the glass tube be located?
Near the top of the inverted flask, towards middle or down into the rock or does not it make any difference?
Why is this?
5. Why should the blue coloured litmus become red in the flask?
6. What property of H.C.L. is illustrated in questions 1, 2 and 3?
7. Which of these illustrate Physical and which Chemical properties?
8. If a piece of dry red litmus paper had been placed in the flask of H.C.L. vapour before the flask was started, what change would you predict should have taken place? Why?

9. If the H.C.L. vapour had been compressed into the flask so that the flask contained, say, twice as much as in the demonstration described and if the same procedure had been followed, what do you think would have happened? Indicate your prediction and reasons why you think this would have happened, then try; if the results are different; ~~can you~~ give the reason for what did happen?

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The above sample question is intended to measure the functional understanding of science. Of course, it measures the mastery of contents which Taylor thinks is essential for reflective thinking. In the annual and the public examinations at least, some questions of the above type may be included. It must be remembered that such types of questions are comparatively better than the ordinary traditional ^{essay} type of ~~essay~~ questions.

There is great need for designing such questions as illustrated above, to evaluate the mastery of laboratory techniques and procedures also. The answers to these questions may be objective or may have alternative or subjective aspects.

Evaluation of other Aspects of Science Instruction:

As indicated earlier ~~very~~ the traditional examinations do not measure some of the qualities which shall be the outcomes of science instruction. So long as we permit this situation to continue it will exert an undesirable influence on the aims of teaching science. ~~It becomes~~ ^{We have} essential to modify the present mode of examination so as to include questions that can measure the above said qualities of the instructional outcome. It must

be realised that there is much more educative value in educating the child through science than merely imparting some ready made facts to be reproduced at the examination. The stress in educational institutions is usually laid on these aspects of instructional outcome that are usually tested by the existing system of examination. If the examination system were to change so as to measure other, more important outcomes, then, there will be a controlling influence on the contents and methods of teaching science.

No doubt, many important outcomes cannot be measured by written tests. At best, they can be measured by an estimate by the teacher. But teacher's estimate will always remain subjective and hence it becomes impossible to standardise. So it is only the written examination that can give us an accurate measure of pupils' ability. Hence we have to make use of the written examination to serve the purpose as accurately as possible after suitable modifications. The science Masters' Association of England suggests a new scheme of evaluation. It has listed the following aspects of science instruction as the items to be tested:²

1. A united range of facts of fundamental importance.
2. The course should cover parts of the three main courses at least (it may be more also)
3. It also should assess certain local specialisations like the topics specially relevant to the school environment or pupils' special interests and abilities.

For this purpose the Science Masters' Association recommends in the report on Teaching of General Science (1950, page 118) that two papers must be set, one for assessing objectives indicating 1 and 2. This must be in the form ^{of} questions admitting short answers or New type ^{questions}, thus providing opportunity to cover the entire field. The other paper should consist of questions demanding Essay type of answers which will enable them to develop activity to organise points and marshall their arguments in orderly sequence or to write down clear instructions for the performance of an experiment. This ability is essential with all cultured individual.³

The questions should try to measure samples of certain abilities if it were to measure the varied outcomes of science teaching. A list of such specific abilities with an illustrative question is given below:-

I. Acquisition of Scientific information and knowledge:

1. Knowledge of empirical facts:

Name four metals which are heavier than copper.

2. Power of reproducing verbally laws or principles:

State the principle of osmosis.

3. Knowledge of technical terms or words used in science:

Explain the meaning of photosynthesis.

4. Ability to identify form, structures, processes and to state their functions:

A labelled diagram of plant may be given. The pupils may be asked to name the parts and state their functions.

5. Power of explaining verbally the meaning of a law or principle:

What is meant by conservation of inter-planetary space?

II. Evaluating Scientific modes of thought:

1. Ability to use scientific knowledge to facts or ordinary life - i.e. unification of experience i.e. from facts to principle - (Generalisation):

Explain: 1. The occurrence of a blue flame that often occurs over a coal fire. ^{of}

2. Why soap forms a curdy precipitate with hard water.

2. Enlargement of experience by recognising in ordinary life instances of the operations of natural laws. i.e., from principles to facts:

Describe three experiments or observations which show that radiation of heat obeys the same laws as light.

3. Capacity to identify facts from hypotheses: Pupils may be asked to find out the following aspects from given statements:~~are~~: 1. facts, 2. verifiable generalisations, 3. mere statements of opinion.

4. Isolation of relevant facts from a complex and elaborate situation:

A certified experiment is described and pupils are asked to pick out relevant facts for the solution of the problem.

5. Ability to plan experiments and test statements:

1. How do you find out that a ~~muscle~~ of frog's leg is extensor and not a flexor?

- ii. Saccharin~~is~~ is 500 times sweeter than Sugar -
Devise an experiment to test.

6. Ability to apply generalisation to new problems.

Two identical cubes of wood are sterilised and kept in moist chambers - Block A is kept sterile. Block B is inoculated with a virus which grows and thrives in wood. What difference do you expect to find in the weight of the two blocks at the end of four months? Why?

7. Ability to draw reasonable generalisations from given experimental data.

In a germination process 9 boxes were kept at 9 different temperatures as shown below:

Temperature °C	6	8	10	13	18	25	30	35	39
Number germinated.	0	0	0	0	16	50	84	30	0

What generalisation do you draw from these data?

8. Ability to recognise problems which lead to scientific treatment and the contrary.

Which of the following statements can be investigated experimentally and in what way?

- i. Rain before seven, five before eleven
- ii. A Hot water bottle~~s~~ airs a bed
- iii. Virtue has its own reward.

III. Application of Scientific knowledge to socially desirable end:

Ability to recognise situations or unsolved problems in which scientific knowl^dge can usefully be employed.

1. A farmer planted seeds in his field that did not germinate; another farmer planted seeds of the same kind of flower plant in the adjoining field. They germinated, and grew. What facts more do you require to explain?
2. A flock of sheep gave birth to many young ones on some days and few on other days? What more facts do you require to explain the cause?

IV. Practical powers or Mechanical or Manipulatory skills:

Power to talk ^{in a} ~~on~~ common scientific knowledge. Power to use and handle is also important in science. This cannot be tested by ordinary examinations. The students must be placed in specific situations and called to use specific skills. The following are the various types of skills.

- i. Manual skill and dexterity;
- ii. Ability to use scientific material (Laboratory skill);
- iii. Ideals of careful, accurate & neat work;
- iv. Apply knowledge to practical problems of life, and
- v. To devise experiment and conduct them.

School records will give valuable information to test the above aspects of pupils' skill in laboratory work.

The Secondary Education Commission in its report recommends certain changes in the existing system of Examination. The

The Commission feels that the number of external examinations should be reduced. While considering the various elements that go to make the results of our examination unreliable, the Commission suggests, that the element of subjectivity must be minimised. Since a continuous and periodical assessment is essential it recommends that special attention should be paid towards maintenance of the school record. The Commission has also recommended that the class promotional examinations and class records should count for the purpose of final assessment and the marks scored by pupils to be mentioned in the final certificate. The Commission also recommends that a system of compartmental examination should be introduced as it exists in England.⁴

The above recommendations fall into three main groups:

- i. Reducing the importance given to external examination.
- ii. Maintenance of a system of ~~cumulative~~ records,
- iii. Basing our testing on objective type of questions.

The above three features are really the trends in the field of assessment in ~~the field of~~ progressive countries. The Government of India following the recommendations of the above Commission, has already set up a council for the reorganisation of examination in India. The State Governments are also trying to modify their system in accordance with the central directive. The following are the trends in the schemes of reorganising examinations in the different States of India.⁵

- i. Short answer type and objective type of questions are being introduced.

- ii. Maintenance of ~~com~~ulative record;
- iii. To consider marks of class tests and class records for purpose of final assessment. 20% of the total marks must be class marks of the final year;
- iv. Even for deciding annual promotions the marks obtained in class records and tests should be taken into account;
- v. Every question paper should include ordinary essay type, short answer type requiring pointed answers and the new type tests,
- vi. Out of 100 marks allotted, 50 marks to be assigned for essay type of questions, 25 marks for short answer type of questions and the remaining 25 for the new type tests.

In every State schemes for the reorganisation of the system of examination are being prepared. Suitable types of ⁱ ~~u~~ ^m cumulative records are also being drawn up. The introduction of the short answer type and new type questions will however, remove some of the defects of the present system of evaluation. The maintenance of cumulative record will certainly go to evaluate some of the attitudes and appreciations of the pupils. Sooner or later at some stage or other, we have to include tests for measuring the development of attitudes, appreciations and skill in problem solving.

B I B L I O G R A P H Y

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1. Heiss, Obourn and Hoffman - Modern Science Teaching - Reproduced from pages 191 - 192.
2. Science Masters' Association of England - Suggested Scheme for evaluation.
3. Science Masters' Association of England - The Teaching of General Science - Page 118.
4. Ministry of Education, New Delhi - Report of the Secondary Education Commission, 1953. Pages 146-147.
5. Secondary Education Board, Mysore - Report of the Sub-Committee on Examination Reforms on the lines suggested by the Central Ministry of Education.



CHAPTER XVII

PREPARATION OF SCIENCE TEACHERS.

The rapid changes that have taken place from the beginning of this century in culture patterns have inevitably induced corresponding changes in the theory and practice of education. This has necessitated reorganisation of the systems of education all over the world. The tempo of reconstruction of the educational system varies from country to country in accordance with the nature of the administrative machinery. This reconstruction has in its turn, influenced the preparation of teachers. This influence has been in the form of a demand for the preparation of teachers with improved material conditions and higher standard of professional education.

When education meant imparting a mastery of contents the teacher was a craftsman successfully using the most 'approved tricks of the trade'. To-day teaching involves not only imparting certain prescribed contents but sympathetic understanding of the place of knowledge in the growth of each pupil and its value to society. The teacher can no longer simply impart doses of curriculum. He cannot merely rely upon his own cultural background but also upon principles that guide him in helping each pupil to realise his potentialities to the fullest. So there is a shift of emphasis from the subject to the child. This has been a shift of emphasis to the teacher who has to understand both the child and the meaning of the subject or what he teaches in a particular cultural

environment. Thus there is a change in the nature of the preparation of teachers from that of apprenticeship to one suited to a profession.

There is a corresponding change in the administrative policy related to teachers' training institutions. If the teacher is to be prepared to man the institutions, such as to achieve the changed objectives of education the best type of organisation and administration of teachers' training institutions should be based on the principle that the teacher should be so educated that he can be released for his proper work under the best possible conditions in which reorientation and uniformity can have no place. It merely means that there must be flexibility in the courses of studies and programme of work of those institutions so as to facilitate the teachers to have a broad-based professional education.

The status of teaching has therefore changed from that of a trade to that of a profession. The findings of psychology and sociology are being applied to the art of teaching as a result of which the teachers' preparation has undergone practically, ^othough ~~a~~ revolution. The work of preparing the teachers is no longer a mere equipping them with the 'tricks of the trade' but to provide a scientific and technical type of professional education. As expressed by the American Association of Colleges for Teacher~~##~~ Education in their book "School and Laboratory Experiences in Teacher~~##~~ Education", the preparation of teachers has thoroughly changed because of the impact of the changing concept of education

on the one hand, and the principles of individual and social behaviour on the other. In fact, preparation should aim at a broad educational programme to equip the teachers with a wide range of competencies both as persons and as professional workers. Meanwhile their general education should form the basis on which their professional education should be scientifically designed. Many aspects of that general education form part of teachers' equipment. The technique of teachers' preparation is mainly and broadly concerned with the work of assisting the prospective teachers to see the interrelatedness between their general education and professional education. It is in the light of this principle that the scheme for the preparation of science teachers should be organised.

Trends in Teacher~~ing~~ Education in U.K.

The changes in the scheme of teachers' preparation both at the degree level and at the under-graduate level induced by the changes in the concept of education and the changed demands on the school are reflected in the McNair Committee's Report, 'Teachers and Youth Leaders' published in 1944.¹ Among the various recommendations made by the Committee the most significant one is that the teaching at the primary and secondary level should be recognised as a unified profession with a unified basic salary scale. The committee also recommended that all teachers should be denominated as qualified teachers after a period of professional training. Since teachers are remunerated by public authorities the Ministry of Education retained the power of awarding certificates to

teachers but the examinations were conducted by the Area Training Organisations (A.T.O.) which were also established following the recommendations of the McNair Committee.² The A.T.O.'s are professional organisations immediately concerned with the work of training teachers. They are intermediary organisations between the University on the one hand and the Training Colleges, Local Education Authorities and Teachers in service, on the other. Their functions include supervising courses in the member Colleges and recommending to the Ministry for the award of the status of qualified teacher, to those pupil-teachers who have completed their professional training successfully. They are also concerned with the planning for the development of training facilities, with the work of providing educational centres for students and teachers in service and with the work of organising facilities for further education of teachers in the area. Each A.T.O. also tries to maintain standard in the area by its academic and professional boards on which the University will be represented. This is further ensured by appointing external examiners to its boards from outside the area.

Another important recommendation of the McNair Committee Report was to start "A National Advisory Council" on the training and supply of teachers (N.A.C.). This Organisation was set up in 1949 by the Ministry of Education. All the A.T.Os are members of this Council. The function of this Council is to keep under review the national policy of training and conditions of qualifications of teachers and on the recruitment and distributi

of teachers in ways best calculated to meet the needs of the schools or other educational establishments.

As a result of the implementation of the above recommendations of the Committee the work of preparing teachers has undergone some changes in some significant directions.

Courses in the Two Year Training Colleges:

The organisation of the A.T.C's has brought about a definite reorientation in the work of the two year training colleges. These colleges were mainly devoted to the preparation of teachers for infant and primary schools. They were 114 in number in 1954. Each of them had its own distinct origin and individual tradition and even remained aloof from the other till 1954 when they joined in each area to form an Institute of Education. The Organisation began to break down the isolation of training colleges by bringing together the different ^{training colleges on the one hand and linking them} with the University Departments of Education on the other. As a result of this there was facility for following common policy and to establish common standards within the area. The National Advisory Council brought about similar effects but on a broader and national basis. The A.T.C's and N.A.C. did respect the traditions of the individual colleges. They were allowed to retain their independence and to function as autonomous institutions under their own governing bodies and staff. This flexibility was essential to ensure scope for experimentation and progress. As a result of their newly developed contact with the University departments of education the training

colleges had the benefit of academic contract and the opportunity to improve their professional standard.

The training colleges offer courses in academic and professional studies and in practice of teaching for two years. The students are expected to study one subject to a deeper level and another subject which is optional. The first one is the subject which he is expected to teach. It is this subject that forms the subject of their specialisation. Special methods of teaching ~~are~~ taught in connection with the instruction of the particular subject.

There is provision in the training course either to select teaching of Nature Study or Science. The course generally includes theory and practice of teaching ~~the~~ subject. There is a laboratory where pupils get trained in the laboratory technique. In addition to the methods of teaching science, some aspects of the subject also will be taught. This is particularly necessary in the case of those who go to modern schools to teach.

Some colleges have attached practice ~~teaching~~ schools. But generally they prefer to have regular schools for the purpose. Usually the students will have to teach for 12 weeks. A wide variety of schemes of practice teaching exists. Provision is made for observation visits in connection with the study of child psychology. There will be twelve weeks of practice teaching under the supervision of all the members of the faculty. Members of the staff both academic and professional, go to supervise

practice teaching. Usually every member of the staff is attached to certain school. The practice teaching is intensive and such as to provide teaching and laboratory experience essential for a science teacher.

The students in the training colleges do not get their notes of lessons corrected before handling the classes as this is not possible under the block system of practice teaching. They do not write elaborate notes of lessons since they have to do 2 or 3 or more periods of work every day. But they do prepare a sort of lesson plan, which include 1. statement of objective 2. Apparatus and appliances required. 3. An introduction. 4. Development and 5. Conclusion. 6. B.B. work and summary.

As a result of the increase in the upper age limit of compulsion by the 1944 Act a new impact has been felt on the work of the Training Colleges. The teachers who come out of the Colleges will have to teach children in modern secondary schools. But their academic qualification is not much more than that of the pupils they have to teach. Hence it was found necessary to give them opportunity to study more of their subject matter. So, all the training colleges have improved facilities for providing advanced instruction both in the theoretical and practical aspects of science. Science teachers will have an advanced course in theory and an intensive course in practical side of the subject. To keep up the academic interest some of the lecturers and Professors of the University Departments of Science will go to the training colleges and lecture on their special subjects.

Even the above provision for providing further education in science to the prospective teachers was felt inadequate to equip teachers to teach science in Modern Schools. Some colleges like St. Paul's Training College and St. Mary's Training College at Chaltanham decided to extend the period of the course by one more year. The third year was devoted entirely for studying advanced aspects of science subject. This tendency spread by 1956 to a number of other colleges. The Ministry of Education realising this need, decided to increase the period of training in all colleges, ^{two} from, to three years ⁱⁿ 1957. Now, the country has to implement the third year additional course from 1959-60. Meanwhile serious controversy is going on as to what type of course is to be provided in the 3rd year

Training of Science Teachers in the University Departments
of Education:

The formation of the A.T.Os. which brought the University Departments of Education into close connection with the two year Training Colleges on the one hand and the teachers in service on the other helped the University Departments to acquaint themselves with the actual position of the schools and the particular way in which they have to train teachers for the secondary schools. The age long objection that the University Departments nearly produced theoretical experts and not practical teachers, could now be remedied. As a result of the efforts on the part of the University Departments of Education to make their courses more practical, we notice certain particular changes in the preparation of science teachers.

Till then the course in the methods of teaching Physical

Science or Biological Science consisted theoretical and practical aspects. Theoretical work mostly consisted of lectures on the scope, objectives, methods and other aspects of teaching the subject. It is this feature that courted much criticism. Nowadays there is a reorientation of the emphasis from the theoretical aspect to the practical methodology of the subject. Though they do attach importance to theory it is done in close co-ordination with practice. When they have to deal with certain approach to the teaching of a topic, the methodologists actually demonstrate the particular approach in the teaching of that topic with all apparatus and appliances and even permit pupils to discuss to what extent such an approach is advantageous.

Tutorial work is increased in the special subject. The pupil-teachers prepare for teaching topics and demonstrate the same before their method masters ^{and} classmates. Discussion will take place on the lessons demonstrated. The teacher also will participate. This preparation for the teaching unit has two objectives - firstly, the pupil-teacher will acquaint ^{himself} with the subject matter, way of approach, aids required, etc., as he has to ~~take~~ the same topic for practice teaching; secondly, it helps him to know how to prepare himself for the lesson. Every student under training will have opportunity to demonstrate ~~before~~ before the class, his preparation for teaching topic and receive the suggestions from his class-mates and tutor. Their elaborate preparation in the subject proper, procuring of suitable aids, demonstration of experiments, efforts to design the most effective and economic approach to the topic, discussions and suggestions by

the group will serve as an efficient background in training a practical science teacher for the secondary schools.

Practice^{of} Teaching:

The system of practice teaching varies from University to University. Normally pupil-teachers will have to teach for 12 weeks. Some University Departments will have one term reserved for practice teaching and there will be no theory in that term. This is so in Bristol University. In other Universities like the University of London part of the term will be devoted for practice teaching and will spread over the whole of the year or two terms. Anyhow Block system, either completely in one term or spread over more than a term is a common feature. After completing practice of teaching, the pupil^{teach} meet their subject method^{of} list during the next term to discuss some of the problems arising out of their practice^{of} teaching.

Pupil teachers will have to participate in the subject seminars to be arranged in the short vacation. In some Universities like London University Institute of Education the seminars and workshops are held in regular classes. For those pupil-teachers who are specialising in the methods of teaching science, provision for practical or laboratory work is made in a number of Universities. It is felt that this provision specially equips the teacher with the ability to manage the laboratory and conduct the experiments successfully in the class. Some of the University Departments of Education where there is no such provision are seriously trying to equip themselves with science laboratories.

Tests and Examinations:

Some of the University Departments of Education in U.K. do not have an examination at the end of the course (Post-graduate certificate in Education, equivalent to B.Ed. or B.T) as in the University of Bristol. In other Universities the Departments of Education do have an examination at the end of the course, as in London University Institute of Education. If there is no examination at the end of the course there will be a system of continuous evaluation of the work of each of the pupil-teachers from the beginning to the end. The Head Masters of the school where they ~~are~~^{practice} pupil-teachers will usually assess their work in the practical side. They will submit a report at the end of the period to the Department of Education. If there is no examination at the end of the course their opinion will be taken into account while evaluating the work of the pupil-teachers in practice teaching. If there is an examination the headmaster under whom the pupil teacher worked, may be appointed as an external examiner.

Both the Training Colleges and the University Departments of Education will have to submit lists of teachers to their Institute of Education after satisfying themselves with regard to the progress of the teachers under training. The Institute of Education will get the list certified by the Ministry of Education. The trained teachers thus become eligible to teach.

A special feature of the English Training Colleges is the provision in a number of them, for the study of Rural Science. Ex-

Extensive fields and laboratories are provided for the purpose and teachers with an intention to serve in the rural schools, evince great interest both in the theoretical and practical aspects of the study of the subject. Topics like Soil Constituents, Poultry farming, Sheep Breeding, Bee-keeping, Agriculture, Horticulture, Rearing of Animals and Plants under temperature control, etc., are studied both in its theoretical and practical setting. Such teachers with their special training in Rural Science certainly, can teach science in the rural schools with adequate insight into the particular problems of rural life.

Training and supply of Science Teachers:

In recent years English Schools have felt the need for teachers in greater numbers and of more diverse kind than ever before, partly as a result of the increase of pupils under instruction and partly as a result of the widespread aspiration of the nation to raise the quality of teaching provided. Long planned experiments have been launched. Revision of curricula, overhauling of examination procedure and a review of training principles and practices have taken place. Hence a ^{new} responsibility had to be shared by the Training Colleges on the one hand and the University Departments of Education on the other.

In England and Wales there is diversity of responsibility among the training institutions. This necessitated the Minister for Education to see that the supply and requirements for trained teachers matched. It is to assist him in this great task that the standing

and

'Advisory Council on the Training, Supply of Teachers' was constituted in 1949.

The Council in its report of 1953 on the Training and Supply of teachers has expressed the idea that there was a serious shortage of science teachers particularly as a result of the competition of industries and the University Post-graduate departments in employing. The Council realised that if this shortage were to continue there would be a serious adverse effect on the general quality of education of the nation and on the future supply of scientists and technologists. The Council recommended to the Minister of Education that the following measures may be adopted to avert the adverse effect of the shortage of science teachers:³

- i. Since the financial prospects are the main factors that attract ~~the~~ science teachers to the teaching profession, suitable salary scales may be fixed up for science teachers;
- ii. Though the superannuation limit is fixed at 60 there is a tendency among the teachers to work on beyond the retiring age. Hence at the discretion of the science teachers and that of the local education authorities they may ^{be} kept till 65 or beyond;
- iii. There are ~~a number of~~ women who are married but prepared to work in the schools for some hours in the day. In some places they are the only persons to be employed. Hence the married women may be employed as part-time science teachers if they have adequate qualifications;

- iv. A large population of science graduates are employed in the University Research Sections and Industries. No doubt, they may not be proficient to teach school children. But as a temporary measure they may be employed as part-time teachers in schools;
- v. In competing for science graduates to-day the schools are up against strong counter attractions. The Scientists in schools think that the Industries and University Research Section can offer them ample facilities to do research work and make their original contributions to the progress of science.

The ~~country~~ has considered that the problem of supplying adequate number of well trained teachers is one of national importance. So, the Ministry of Education has announced in recent days a big plan for expanding Britain's Teachers' Training Colleges. This has been announced by the Government as the biggest permanent expansion scheme, ever undertaken, ~~as announced on 6th February, 1958.~~ The programme costs over £ 15,000,000. This programme will considerably increase the number of large colleges of 400 to 500 students each. It is expected that those colleges will provide both academic and professional education as effectively as University Departments of Education. In this programme the Ministry of Education lays special emphasis on the training of more and effective science teachers.

The launching of the above plan is a capital undertaking in the

field of education. The nation has realised the importance of Teacher Education in the progress of the country. It has also realised that an adequate and efficient provision for the training of science teachers is essential for the production of scientists and technologists to man their industries and thus contribute for the strengthening of their national economy.

Science Teachers' Training in the United States of America:

Though there is a strong faith in education in the United States of America in recent years teachers were subjected to disgraceful treatment in the name of the national defence by asking them to take the oath of loyalty and to sign statements that they would not join subversive activities, etc. Further, the schools are seriously criticised for bad work.⁴ As a result of the above two developments in the political and social life of the nation there is an unwillingness on the part of the young and intelligent people to take up ^{jobs} as teachers. Even salaries particularly for science teachers are not as attractive in teaching profession as in other professions. Naturally capable people are prevented from taking up teaching jobs. But there is a continuous increase in the enrolment of pupils and more and more teachers are required. The enrolment in 1949 - 50 was 2.86 crores in secondary ~~schools~~ and elementary schools. It is expected that it will increase by one crore in 1959 - 60, due to heavy birth rate during and after the war.⁵ They had to employ all those who can come to teach. And most of them are people who could not think of other lucrative jobs because of their inability to get them. This has resulted in the lowering of the teaching efficiency on the one hand and the dilution

of the quality and standard of education and lowering of the status of teachers in scarcity, on the other. This is certainly an unexpected development in the American Educational scene and is sure to have drastic effect on the progress of education. It is possible that the nation has been made to weigh the worth of professions in terms of their contributions to improve its defensive and offensive capacity only.

Financing of schools in U.S.A. is a local problem where as standards of preparation and certification of teachers are state problems. They have fixed up the minimum essentials but it is to local authorities to mix up any thing above the minimum. The Federal Government does not take any active part in the above work but publishes informational publications. Those publications are of great help in improving the standard of the profession. Some of those reports are cited below:

- i. The National Survey of Education of Teachers - 1935
-by the U.S. Office of Education;
- ii. The Improvement of teacher education - 1946-by the
~~by the~~ American Council of Education;
- iii. The Education of teachers as viewed by Profession -
1948-by the National Education Association (N.E.A.);
- iv. The Teaching profession grows in service - 1949-by
the National Education Association;
- v. A number of Annual Bulletins - on the progress of
Theory and practice of teacher Education -
by the American Association of Colleges for
Teacher. Education.

Institutions for Teacher Education:

There were in all 1093 institutions for teacher education

⁶
in 1952. They are of three types, namely:

1. Normal Schools;
2. Teachers' Colleges;
3. Liberal Arts Colleges with Education Departments *and*
4. Schools or Colleges of Education of Universities.

The Normal schools offer courses of two years to elementary school teachers. The other institutions offer four or five year courses for elementary or secondary school teachers. The latter institutions admit only pupils that have graduated from a high school. There is diversity in the duration of teacher education and it varies from one to four years of preparation of elementary school teachers and from two to five years of preparation for a high school teacher. The certificate will define what subject he should teach.

At present, there is a confusion in America as in England as to what amount of professional studies should be included and ^{to} what extent academic subjects should be studied in the teacher education courses. The tendency is that the teachers should be broadly educated persons, thoroughly conversant with the subject they teach and that the time spent on education should not encroach too much on the time that should be devoted for general cultural education. Usually 1/8th of the time is devoted for professional studies, and practice of teaching. This requirement is prescribed by the States for purpose of Certification.

The curriculum and courses of studies in teachers' training institutions are strongly influenced by the changing aims of elementary and secondary education. The movement in favour of extending the scope for studying science as a subject of general education as against

early and narrow specialisation has brought into the curriculum more of science for general education on the one hand and the extensive study of such topics like 'growth and development of children and adolescents', 'meaning of interests' and 'the learning process' on the other. The second trend we notice is that the science teacher in his work should not merely depend on routine skill, prescribed courses of studies and text-books, but he must be able to utilise the application of principles to ^{the} problems of life. The training institutions should provide such a situation to develop those adaptable capacities. Further, there is a change in the teachers' status. The teachers ^{are} being used more and more as advisers and participants in the management of the department of education. So the teachers' colleges have to give them training in curriculum construction and fixing other policies in the field of education.

Whether he is a science teacher or not, a new importance is attached to the place of teacher. They have to be politically and socially alert though they do not actually practise. The science teacher is expected to be industrial minded in addition. His work in the school science laboratory is only part of his work. He has to inspire the activities of the science club and the other hobby clubs like, Photographic Club, Mechanic Club, Flying Club, etc. He has to guide them to collect and prepare science news bulletin. He has to take them for field-trips and excursions and to various centres of industrial importance. Naturally, the training colleges will have to provide suitable facilities for training science teachers in all those aspects. No doubt, they do maintain a practice teaching school or teaching laboratory. But a good number of other schools also will have to be

taken. In addition, various types of Community Service Agencies, Camps, Play grounds, Libraries, Co-operatives are to be utilised; provision and programmes for field trips, excursions and visits to factories are also to be included.

The curriculum of the four year Teachers' Colleges includes subjects of General Education, Specialisation in one or more allied subjects, Professional studies and Practice teaching. Nearly half of the time is spent over the subject of science in case of those who specialise in science teaching.

Those who want to become science teachers in a Secondary school, will have to study upto the standard fixed for the degree. Meanwhile 1/8th of the total time is devoted for professional studies. Then they will get in addition to a degree in the subject, the certificate for teaching also. They may even study for ~~one~~ year more, after taking the degree in the science subjects and specialise in the teaching of science.

The General Education for science teachers in America is rather confused in its scope. In some Universities or colleges it consists of orientation courses in sciences in addition to those in humanities and social studies. In others it may consist of a collection of introductory courses in separate subjects that make those groupings. The purpose of these courses is to enable the prospective teachers to further the development of their knowledge, skills and attitudes and interests that are fundamentally related to their needs and responsibilities shared with contemporaries, destined for other vocations.

In the training colleges there is a trend to integrate courses together just as there is similar integration in school curriculum. The prospective teachers may study the general education subjects in the first two years or distribute the same over the entire period of the training course.

History and Principles of Education, Educational Psychology, Class-room Management, General and Special Methods of teaching and Practice^{of} teaching are usually included in the courses of studies on the professional side^s. The methods of teaching science include lectures and practice of teaching.

Practice^{of} teaching is mainly provided for in the 'Campus' or laboratory schools. Observation and teaching are the techniques through which they improve their skill and ability of teaching the subject.

As expressed by the Dean, Russel 'the American Concept of a Modern science teacher is that he should not be a narrow specialist but possess a broad cultural or subject background in addition to the skill in the art of teaching and being able to assume a position of leadership both in the school and in the community'.⁷

Reorganising our Training Programmes to Turn out Better Science Teachers

At present there is no legislation in any State of India prohibiting non-certificate holders from teaching in a Public or recognised private institution though some States while appointing, appoint only qualified or certified teachers either as a preference or as a policy. Evidently we have in the country a good number of untrained

teachers working in both the primary and the middle schools. "Training for primary school teachers and education for secondary school teachers" was held good even in India for a time, as a result of which the teacher's preparation for the secondary schools is a later effort in our educational history. Therefore we find even in the secondary schools a good number of untrained teachers. As per the Report of the Government of India for the year 1953-54 published in 1956 the percentage of trained teachers in the primary school was 62.4, whereas in the secondary schools it was 56.1%. In the state of Mysore it is comparatively less. The trained teachers in primary school in the same year was 33% and in the secondary school it was 43%. In some States where preference is given to trained graduates while appointing, the percentage of trained teachers will be high.

In the majority of States there are three stages in the pre-university education - Primary, Middle and Higher secondary schools. Even in the Report of the Secondary Education Reorganisation Commission's Report there is a suggestion to have primary education upto 12 and Junior Secondary School upto 15 and Senior Secondary School upto 18. That means there will be three distinct steps even in future. But some of the States are having only two stages - primary upto 13 or 14 and Secondary upto 18. It is clearly evident that the proposed junior Secondary School is merely part of the secondary school. For purpose of organisation, ~~it may be considered that~~ the pre-university education ~~may be considered~~ as two distinct stages, namely primary and secondary. Naturally we have to think of teachers with two distinct levels ^{of} qualifications for these two institutions. The teachers in

primary schools should possess a certificate or having passed the Matriculation or the S.S.L.C. Examination where as those for the Secondary Schools should generally possess a degree of the University. Keeping this in view when we examine the ^{position} ~~teachers~~ we notice that the majority of teachers in the primary school do not possess that qualification in general education. This is because, formerly the qualification prescribed for the primary school teachers was comparatively low. Even in middle schools or junior secondary schools we do not find that all teachers are university graduates. The majority of them possess only S.S.L.C. qualification or its equivalent.. This is not so bad. Teachers in other countries, teaching the same standard, possess similar qualification, though there is a tendency to replace by graduates. In the lower classes of the secondary schools of England Teachers are non-graduates. Similarly in the Junior School of America. So, our problem is to see that all primary schools are equipped with teachers with S.S.L.C. qualification and all secondary school teachers with University degrees. This requirement is particularly essential for science teachers.

The foregoing paras make it clear that both the general and professional qualifications of our teachers particularly in the primary school, is quite inadequate and naturally they cannot make the instruction as effective as it could be. This is particularly true with science instruction since many of the teachers possess only primary school certificate, that too when the courses in that grade did not include the study of science. So, they cannot be expected to teach science. Even in the **secondary** schools, new problem of staffing particularly for teaching science has arisen after the introduction of

general science. Hence That aspect also is to be considered. Hence there is need for increasing the general qualification of science teachers for the primary schools and ^{for the} consideration of the qualification of teachers for the secondary schools; on the professional side facilities for training teachers both for the secondary and ^{for} the primary schools are to be increased. In addition, the reorganisation of education has brought in new problems on the professional side. Our training courses are to be reorganised so as to meet the new demand. Hence it becomes clear that the teaching of science in the new organisational set up, demands an immediate reorganisation of teachers' education at the two levels both in its academic and professional side. The rest of the chapter is devoted to a consideration of how we can reorganise the general ^{and} professional sides of teachers' preparation so as to meet the new situation.

Reorganisation of Teacher Education - (Under Graduate Level):

As indicated earlier an effective science programme depends largely on the efficiency of teacher. His efficiency should be in two fronts. He should be efficient in his subject or subjects and proficient in his work as teacher. The modern outlook on teachers' preparation takes into account both his academic and professional aspects and that is why there is a tendency to avoid the term teachers' training in favour of Teachers' preparation or education. Basing on this conception of teachers' preparation, a number of countries have combined both cultural and professional aspects of teacher education in one course. Hence, while considering the reorganisation of teacher education, we have to deal with the cultural and professional preparatio

of teachers, together. But, for purpose of convenience the two sides are separately dealt with in this book.

The Cultural Side of Teachers' Preparation:

Science being a new subject special attention is to be paid to ensure that the teachers are acquainted with it at least to the extent essential to teach the boys and girls in the primary schools. The majority of teachers now in service, possess very low general qualification. They were educated at a time when there was no science in the primary schools. Others who possess S.S.L.C. qualification, would have studied the subject to some extent. But the general science as introduced in the primary schools now, includes topics of astronomy, chemistry, biology, physics, etc. Hence the teachers who are entrusted with the work of teaching science should have studied science upto the S.S.L.C. standard. No doubt, that is the minimum equipment essential. But the variety of topics that are to be included in the primary school curriculum, requires greater width of knowledge in the field on the part of the teachers. If at all, they could successfully assist the children in getting science experience. Hence, in addition to what science they have studied in the S.S.L.C. class they have to study it in the training institutions to some extent, so that they may know the meaning and scope of those topics which they have not studied in the S.S.L.C. course or which they have not studied upto the requirement.

Professional Side:

Generally the teachers after S.S.L.C. will have to get themselves equipped with the professional training before they could be

entrusted with the teaching work. At present, the education of teachers at this level is for a period of one year in some states and two years in others. Considering the trends in other countries and the particular cultural and professional requirements of teachers for the reorganised primary schools to teach pupils upto 13th or 14th year of age, it becomes evident that the period of teacher education in the under-graduate training institutions should be extended to two years. Then it is possible to give the prospective teachers opportunities to study the different subjects, particularly science, to a deeper and broader level. The teachers should also receive training in the use of laboratory facilities, particularly to prepare some of the simple apparatus and appliances ^{and} to demonstrate experiments to the primary school children.

The teachers should know not merely the content side of the subject but also its relation to society on the one hand, and the pupil and his ability to assimilate the same on the other. This aspect of science should be studied as part of the methods of teaching science. But the course shall not be purely theoretical. ~~men~~ Rather, it must be studied as a body of experience closely integrated with other fields of experiences to be provided to children at the primary stage. The curriculum in the methods course, should be so constructed that importance is given to the work of providing experience to prospective teachers in the most effective ways or approach to the teaching of different topics of the school subject. The subject methodologist may treat in this way, various topics of the syllabus. The course shall also provide ^aadequate experience in conducting experiments with

simple apparatus. This is very important since the teachers in primary schools will have to teach science with meagre equipment. Hence the development of resourcefulness, ~~in teachers,~~ particularly in preparing some simple things and using them for conducting experiments, should be considered as a very important aspect of the professional training, particularly for teaching science.

In this connection it must be borne in mind that there is no need for specialist teachers in the primary schools for teaching any subject. So, the Science teacher of primary school is a general teacher teaching all subjects. Therefore the professional course should be so designed as to enable the prospective teachers to recognise the inter-relatedness of each of the subjects. Hence methods of teaching may be an integral part of the general methods of teaching. Since a single teacher has to handle all the subjects the teacher will have to study the methods of teaching science as part of the general methods of teaching.

The training Colleges will have to introduce the pupils to the newer techniques of teaching science. Instead of sticking on to the text-book method, other modern and alternative methods may be introduced. The Project method, Discussion Method, Unit Method, Seminar and Workshop Technique, the Problem Method, etc., may be included in the courses of study in general methods. The teachers may be specially trained in organising the subject in the unit-problem type and try to teach the same by the problem solving technique, whenever it is possible to do so. Science is being introduced in the Primary Schools of our country since a few years. It is essential to organise

the instruction of the same on proper lines so that the pupils may ensure a proper foundation on which further science experiences can be added on in the higher institutions. For this purpose a proper scientific atmosphere in primary schools may have to be created. This is particularly essential to undo the superstitious beliefs that have been developed in the minds of the pupils. The best way of undoing those elements is to place pupils in situations and activities that are based on realistic ideology. It is felt that the various activities connected with science experiences when properly organised, not merely enrich the science curriculum but also help to develop their love and interest in science on the one hand and the spirit and attitude of science on the other. The prospective teachers of the primary school should be given opportunity in the training colleges, to get experience in organising the following activities as items designed to enrich the school science course:

1. Organising excursions to the various community resources like the Factories, Zoological and Botanical Gardens, Birds' Sanctuaries, Hydroelectric projects, Town-water supply Works, etc.
2. Organising and conducting science clubs, school museums and science fairs;
3. Preparing various charts, and aids to ~~foster~~ scientific interests in the pupils;
4. Use of Projectors and teaching aids;
5. Preparing simple apparatus and appliances out of ordinary Wood, Clay, Plaster, Metal, etc., to serve the purpose of demonstration of some experiments, and

c. Demonstrating interesting experiments.

The Colleges for training of teachers should draw up their programme of work in such a way as to develop in the teacher the professional philosophy of the subject of science instead of training them merely for some skilled job, assisted by a few tricks of the trade. It is their outlook towards science that shall work as a miracle in assisting the children to develop a lasting interest in science and its applications to man-kind. For this purpose some aspects of the biographies of scientists, the role of science in human affairs, the wonders that science is creating and the intellectual adventures of man in the field may be included in the course of study.

Practical Side of the Course:

It is usual for the undergraduate teachers' training colleges to maintain a demonstration or practice teaching institution to serve as a platform for providing practical experience to the teachers under training. Many a time this provision becomes inadequate and hence other institutions will have to be thought of. It is necessary as a pre-requisite of successful practice in science teaching, to maintain a suitable laboratory in the practising schools. A well-planned science room is also essential. The science rooms may be equipped with portraits of the heroes of science to inspire the class room atmosphere. The teachers under training must regularly plan their lessons and get the approval of the subject methodologist. Then they must try to meet the science teacher in the practising school and with his assistance prepare for the lessons. Both the training college

subject methodologist and the subject teacher of the practising school must share the responsibility of training the teachers in the practical side.

Generally, practice of teaching in science is spread over the whole year. It may be advisable to think of introducing block-system of teaching for some weeks at least. This will help the teacher to practise as a full teacher with ~~the~~ all the associated responsibilities. No doubt, this involves various difficulties particularly to provide suitable schools for the purpose. Attempts can however be made in institutions where it can be tried.

In the training institutions of the progressive countries importance is being attached to the organisation of seminars and workshops for teachers under training to provide experience in:

- (a) Curriculum study and evaluation;
- (b) Construction of new type tests;
- (c) Modern approaches to the teaching of topics;
- (d) Preparing working syllabus for class-room purposes;
- (e) Running Science Clubs;
- (f) Organising Museums;
- (g) Organising Science Fairs; and
- (h) Preparation of teaching aids;

The Training Institutions may try to provide opportunities to the pupil-teachers to get experience in the above fields as they go to improve the effectiveness of the training course.

Reorganisation of courses of studies at the Post-Graduate Level:

The work of training teachers is receiving greater and greater attention. This is evidenced by the ~~study~~ increase in the number of training institutions. The following statistical details indicate how during the second quarter of this century, the number of colleges and the number of students under training, have increased in India:

=====		
Year	No.of students.	No.of Colleges

1924	105	1
1932	357	5
1940	730	11
1948	1818	27
=====		

(Adapted from the Report of the University ⁸
Education Commission - 1948-49)

After the advent of freedom this work received greater attention and by about 1950 the number of graduate-teachers under training increased to 3,000 and by 1957 to 12,000. There is a rapid growth both in the increase of the secondary schools and in the strength of the children in the schools. Naturally there was a greater demand by the schools for more and more teachers. In 1953 the total number of children under instruction in the secondary schools was 60,00,000. The teachers working in the same year were 2,70,000. Out of them we may roughly expect that 1/6th of the number may be science ^{teachers} since science forms 1/6th of the school curriculum. Separate statistics however are not available for science teachers. Among them 56.1% of

the teachers were trained. So there was a huge proportion of secondary school science teachers who were untrained. Naturally, it becomes necessary to reduce the number of untrained science teachers. For this purpose efforts are being made to increase the number of post-graduate training colleges on the one hand and to raise the capacity of existing training colleges to take and train more pupil teachers on the other. In 1950, the total number of pupils was 3,000. In 1957, it has increased to 12,000. This four-fold increase is mainly because of the realisation of the need for having trained teachers, on the one hand and the rapid expansion of secondary education, on the other. Along with the increasing of training colleges to expand training programme it is necessary to realise that the quality of the training should also be improved. Therefore, it becomes inevitable that a thorough reorganisation of the courses should take place so as to ensure that the education of teachers at this level can be imparted on modern and effective lines. There is another aspect of teacher education which is more intimately related to this problem - i.e., the Pre-professional or Preservice education of teachers. So we may take up the problem of reorganisation^{of teacher education} after considering the preservice education of teachers.

The Pre-Service Education of Science Teachers:

It is usual to consider the education received before joining the profession as teacher in a school as pre-service education. This includes both the cultural or general education and the professional education. In India the post-graduate teachers' professional education commences after graduating themselves in Arts, Science or Commerce

Their studies upto that period ~~are~~ usually considered as cultural or general education. The teachers through their professional education should realise the implication of the subject they have already studied for the individual and social life of the children to whom it is to be taught and how best that particular subject experience can be provided to the pupils in a certain cultural environment.

In the Secondary schools generally the teachers are specialists or subject teachers, teaching one or two subjects of their specialisation. As already noticed there is a tendency among the curriculum constructors to integrate related subjects into single wholes so that pupils may have a sort of unified and natural type of experience. This tendency has greatly influenced courses or studies meant for the teachers' preparation.

Need for a Broad General Education for Science Teachers:

At present the secondary school science teachers possess a degree of the University. Usually they will have studied two or three branches of science in addition to English and the mother tongue. Those who are Honours graduates will have specialised only in one branch of science to a deeper level and in another to a comparatively less deeper level. This was probably a suitable type of science education for teachers in the secondary schools when science was studied there in the form of its special branches like Physics, Chemistry or Biology. In recent years, attempts are being made to have a course of general science in the secondary schools. Naturally for teaching such courses the teachers should possess a broader knowledge of science. They must

have studied as many branches of science as possible at the degree level. Such a facility is provided by the survey courses that exist in some of the American Universities. However attempts are being made in some of the Universities of India to offer integrated science courses to the science students. In the University of Mysore there were such combinations as Physics, Chemistry and Biology. Such ~~xx~~ combinations will certainly provide a broader experience to the science teachers in the subject which they intend to teach. Four of the academic branches of science are thereby studied by them. But in recent days in all the Universities the number of science subjects is restricted to two only - one major and another minor. Though such a course ensures deeper study of one or the other branches of science it fails to provide adequate breadth of experience. Such graduates may be suited to teach the upper classes of the secondary schools where pupils may be permitted to specialise in one or the other branch of science. But such science graduates like the honours graduates of the earlier days, are not suited to teach general science which includes topics of Physics, Chemistry, Botany, Zoology, Geology, astronomy, etc. Therefore attempts are made to introduce the following types of new combinations for B.Sc. examination in some Universities:

- | | |
|---|---|
| 1. General Science - Major
Chemistry - Minor | 2. General Science - Major
Physics - Minor |
| 3. General Science - Major
Botany or Zoology
or Geology - Minor | 4. General Science - Major
Biology - Minor |

If such combinations are offered the courses of studies in general science for each combination should vary. In the first combination General science will not include many of the academic aspects of

Chemistry as it is to be studied as a minor subject by those who select that combination. In the second combination the general science course differs from that of the first combination as it does not include the academic topics of Physics. Similarly the general science course of any combination does not include topics of the particular minor subject which is studied along with it.

If such courses are introduced the intending teachers can have a broad-based science education which is so essential for teachers to teach general science in the secondary schools.

Another suggestion to provide a suitable cultural education to intending teachers is to have a four or five year degree course in which the professional course also is integrated. In fact, such ~~an~~ integrated courses are found to function satisfactorily for other professions like medicine, engineering, commerce, veterinary, textiles, agriculture, etc. Such a four or five year degree course in which education (both its theory and practice) is integrated is considered by some thinkers as the best type of course. Such Colleges are institutions that can provide both the cultural and professional education to teachers. The only argument against such a reorganisation of courses for the graduate teacher education is that teachers commence their professional practice before they are culturally mature. Such a criticism applies to other professional courses also. Such a course of teacher education is not ^{un-}common in England and quite common in the continental countries and America. In the new British University of North Staffordshire however, education is integrated in a four year degree course. Such an integrated course can certainly provide a

better type of teacher education. But such colleges ~~in India~~ do not exist. ^{in India.} But education is however offered as a cultural subject in the degree course, ^{in some universities} but it does not include practical aspect of the subject.

Until we can find support for starting such institutions for teachers' preparation it is unavoidable to think of two different and separate institutions for teacher education.

With regard to the preparation of science teachers the existing science course at the degree level, should be so reorganised ~~so~~ as to:

- i. provide a broader experience of the subject of science in general;
- ii. include more of cultural and methodical aspects of science;
- iii. provide better practical experience, and
- iv. provide better manipulatory and mechanical ability and skill.

Teachers for Teaching The Special Sciences:

In the new secondary schools science is one of the electives and pupils are allowed to specialise in any two branches of science. Naturally, those who select science as an elective subject may specialise in those particular branch or branches of science later, in the University. Therefore they have to study the subject with an academic interest. Whether such a specialisation as early as 13+ or 14+ is advisable or not is a different aspect of the problem. But

we have also to consider the problem of preparing teachers for teaching those who specialise. Further, the preparation of such science teachers is unavoidable for teaching science at the pre-university level. Some may go to the extent of saying that no professional preparation for such teachers is essential. Yet the cultural aspect of the teachers preparation at least is to be considered here. Many educators consider that a good master's degree in science is quite adequate for teachers who have to teach such pupils who are specialising. For a teacher who is in charge of pupils, specialising in Chemistry at the University level should possess a good degree with Chemistry as a major subject and physics as minor. But some do feel that he should possess a Master's Degree in science. In the lower grades of secondary schools there is no need for such specialisation on the part of the teachers for handling science as a special subject. It is enough if they have studied that particular subject in their degree course.

The Professional Side of the Problem:

Since the first Conference of the Training Colleges that met at Baroda in 1950 attempts are being made to reorganise the courses of studies relating to teacher education at the post-graduate level. The efforts of the successive conferences held at Mysore, Bangalore, Hyderabad, etc., have resulted in the recommendation of a scheme of reorganisation of teachers' college courses. The reorganisation as suggested by the conference is on the following lines:⁹

1. The candidates for teacher education courses must be selected after administering intelligence tests,

personality assessment and interview. In fact this may be supplemented by taking into consideration their performance in the degree examination. The candidates must have studied two specific subjects, one at the degree level and one at the S.S.L.C. level;

2. The candidates who come for teacher education should again experience in the newer techniques like seminar method, workshop method, discussion class, tutorial work, etc.,
3. There may be only four subjects in the theory group. One of them should be the study of the methods of teaching two of the school subjects;
4. Better provision for practical work should be made. This should include, among other things, studying the school science block, laboratory and its organisation, etc;
5. In the examination 50% of marks should be set apart for theory and the other 50% for practical;
6. Practice teaching should include 2 weeks of block teaching. 15 lessons during this period should be given. The rest of the practice teaching may be spread over the remaining year and each candidate may give 15 lessons atleast;
7. There may be atleast one teacher on the staff, for every 10 student-teachers;
8. There may be an internal examination instead of an external one so far as practical is concerned. 35% of the marks may be insisted for a pass;
9. Arts and crafts laboratories may be added to all teachers' colleges.

The above scheme reduces the number of subjects to five on the theory side, thereby giving greater importance to the ^{methods of teaching} special subjects, like, science and other school subjects. The importance given to practical aspect both in the examination and in the training course, in the allotment of time, is particularly advantageous for providing efficient training in the teaching of science. The suggestion for organising separate laboratory ensures facilities for science teachers, to get trained in such laboratory techniques like micropreparation technique, handling some of the technical apparatus and appliances, glass bending, glass blowing, glass welding and in the art of managing the laboratory.

In addition to the above, I may suggest a few more items of reorganisation in the work of the teachers' colleges with particular reference to the education of science teachers.

While selecting teachers for the training course it must be insisted that they should have studied as many science subjects as possible in their degree course, that find their direct application to secondary school subjects. A candidate who has specialised in one branch of science lacks the width of knowledge in the subject of science as a whole. It is the width that counts in teaching general science, particularly in the lower grades. If such broad science courses do not exist in the Universities it is high time, we must take suitable measures to institute such courses as the survey science courses, particularly in the interest of getting suitable science teachers for secondary schools.

At present the work of the training colleges is generally

criticised to be more theory-centred. This particularly applies to the training of science teachers. Lectures include some aspects of the scope, aim and methods of teaching the subject. Rather, the theoretical aspect should include treatment of topics which are to be taught in the secondary school. The Method masters may demonstrate in the class the particular approach to the teaching of many of the major topics. This will help the teachers under training, to connect their knowledge of the theoretical aspect of the methodology to its practical value. Hence the courses or studies under theory, may include as the major part, approach in the teaching of topics or treatment of topics.

During the course of the year, the method master in science may hold seminars, workshops, discussions etc., to train the teachers in the newer techniques in which science can be taught more effectively. Since activity is the essence ^{of} any good technique of teaching science the teachers under training may be given opportunities to gain experience in the organisation of certain science activities to children that go to help the teacher and pupils to realise the objectives of teaching science. Naturally, a good number of science activities are to be provided as part of the course, for training science teachers. If they are merely called as extra-curricular or cocurricular activities the teachers may not take sufficient interest. They must be treated as correlated activities and should be treated as part and parcel of the regular course of study in science methods. The organisation of science museums, science exhibitions, science discussions, starting and running science clubs, issuing of science news bulletin, organisation of excursions to factories, fields, botanical gardens, etc.

should be insisted as part of the course for science teachers. A systematic evaluation of their participation in this work may be made, and it may be considered for purpose of examination and certification.

Another aspect of the reorganised courses of studies is to provide adequate tutorial assistance to the teachers both in their special subjects and in other subjects. It is by this means that the individual difficulties are diagnosed and remedial measures are sought. The problems and difficulties of individuals differ from ^{individual} to individual. Naturally it is possible for the staff to pay individual attention through tutorials. ~~Further~~ Even when group tutorials are held, those groups ~~must~~ ^{be} small, ~~and~~ ^{so that} individual attention will be possible.

Practice of Teaching:

In many of the teachers' colleges the practice of teaching at present, is spread over the whole year. Each student will give two lessons per week, one in each of the subjects in which he is specialising. In a few colleges "block system" is practised. The 'spread over' system has certain advantages. The pupil teachers as they have to give only two lessons in a week, can go to the class with good preparation. Further, since their practice is spread over the whole year they will have ample scope for reflective thinking over the particular problems arising out of their practice teaching. Similarly, certain other advantages do exist in the block system of practice teaching, ~~also~~. The pupil-teacher will have opportunity to work as a full teacher and gain the manifold experience of the

profession. Particularly the science teachers will have ample scope to know various aspects of laboratory organisation and up-keep and the use of the apparatus and appliances. They can also gain experience in conducting practical classes and in the activities of the school science club, field trips, etc. Hence it becomes evident that a good system of practice teaching should try to include the above two types. The pupil-teachers may be asked to go for block system of practice teaching for some weeks. They may have spread-over system for the rest of the year. If block system is followed, during that period the college will have to suspend lecture work.

Whenever there is "block system" of practice of teaching, the pupil-teachers will have to be informed about the topic they have actually to teach in a particular school, well in advance. Each of the pupil-teachers will have to prepare for that particular topic. The topic may include a number of lesson units. The concerned pupil-teacher will demonstrate his preparation before his subject specialists and his classmates. He will, in the case of each lesson, elaborate the way of approach, the particular problems he raises and the particular teaching aids he uses. The group, under the supervision and guidance of their method master, will discuss and offer their own suggestions to improve his way of procedure. Thus every teacher will make a thorough preparation ~~work~~ with regard to contents and methods, for the work he has to do. This enables the teacher to teach the subject in the best possible way. That is why the lessons given by some of the pupil-teachers ^{under the above scheme} are much appreciated even by experienced teachers.

In addition to the actual teaching practice the teacher under training should have adequate opportunities to observe the ^{demonstration} lessons of both the ~~demonstration~~ lessons to be given by the staff members and the practice lessons to be given by their own classmates. They must also get experience of evaluating the teachers instructional procedures by participating in the criticism classes.

Since in the new scheme of the training course, the pupil teachers are expected to do practical work in every subject and marks are set apart for the same, it is possible in the case of science teachers under training to gain experience in the following aspects:-

1. Acquaintance with the school science room and laboratory;
2. Organisation and equipment of the science laboratory;
3. Preparation of some of the teaching aids useful for ~~the~~ lessons;
4. Experience in managing the laboratory;
5. Experience in manipulating glass, metal and other materials to prepare simple apparatus and appliances;
6. Experience in assisting pupils in collecting materials for issuing science news bulletin and
7. Experience in assisting pupils to organise and conduct science clubs.

The practical aspects of the course as elaborated above can be better provided particularly when the teachers' colleges have their own practising high schools. Even when they have to go to private schools for purpose of practice of teaching such experiences can be provided if block system is followed for some weeks.

Cultural Aspects of Teacher's Education:

As science is growing rapidly and ^{the} broad concept of teacher's education includes not merely the professional side but also its cultural side, attention is being paid to provide experience in one subject in which they are specialising, in its content side also. This of course, becomes part of the regular work of the Institution if education is integrated as one of the subjects in the four or five year Degree Course as in the liberal Arts Colleges of America. In case of independent teachers' colleges also lectures, seminars, workshops etc., can be had on various aspects of science which they are going to teach later on. This is possible when the training colleges seek the co-operation of the other science departments of the University. Then, the new concept of teacher education that the teachers should not merely keep abreast of the growth of their particular subject of specialisation but also see it in full relation to application to the life of the pupils to whom they have to help in learning it can be fully appreciated.

In-Service Training of Teachers:

Education is a life long process and it is particularly true with teachers. Our concept of educating the children is continuously changing. The technique and contents of instruction are also changing very frequently. Naturally, a teacher in profession, though once educated and trained, requires further education and training. This aspect of teacher's further preparation is generally known ^{as} in-service education. The subject of science is particularly growing. The interstellar space exploration which was merely a poet's dream a couple

of years ago, has now become a reality. The concept of the ultimate nature of things that we had a decade ago, has now been greatly modified. As a result of this rapid growth of science both in quality and quantity, the teacher cannot merely teach what he learnt and how he learnt as a student. Further, the technique of teaching is also changing. No other aspect of science education has undergone so much improvement as that of its teaching technique in recent years. Hence it makes all the more necessary, that a regular provision for in-service training of science teachers must be made in our educational organisation.

The in-service education of teachers resolves into two faces - the content side and the professional side. It was till now considered that the teachers' colleges should be responsible only to the professional side of it, whether it is pre-service or in-service education of teachers. Now the philosophy of training of teachers has changed. The teachers' colleges can no longer content themselves by merely providing some "tricks of the trade" to the teachers under training. Now they have to help the teachers not merely to understand the children but also to understand the subject in relation to the children. So they have to take this double responsibility of providing both the professional and the cultural aspects of their education, particularly for teachers in service. One may say that the staff of the teachers' colleges may not be proficient and up-to-date in the content side. Though this argument may hold good nothing prevents the teachers' colleges from securing the services of the experts from the various science departments of the university for this purpose.

Types of Inservice Education:

Inservice education can be organised for teachers on the following lines:-

- (a) Day lecture courses on science topics and science teaching techniques by experts, now and then, according to a regular programme may be organised.
- (b) Week-end courses extending over one or two days on the progressive aspects of science or on progressive methodology of science teaching may be arranged.
- (c) Short vocational courses extending over a week or so, may be organised in the short vacations. Workshops, seminars, lecture courses on broader areas of the topic and progressive aspect of science education may be organised.
- (d) Long vacation summer courses, extending over one or two months leading on to the award of certificates in certain specific aspects of science education, may also be held. The method of diagnosis, remedial programme in science teaching, technique of evaluating the instructional outcomes, the method of searching for science talents, curricular reconstruction in science, adaptation of basic science syllabus, preparation of working syllabus, preparation of teaching units and teaching aids etc., may be selected for long term courses from the professional side. From the cultural or subject side, advanced course in general or particular science, progressive developments in science, newer applications of science etc., may also be organised.

Most of the items of the above programme can be organised in every teachers' college. In England they are organised by the Area Training Organisations. Until we can think of such co-ordinating organisations in India, the work is to be shared by four agencies, namely:

1. University Departments of Science for programmes on general or cultural side;
2. The Department of Extension Service for professional courses;
3. Teachers' Colleges for Professional and Cultural courses, and
4. The State Departments of Public Instruction and their Local Administrative Institutions for Cultural and Professional programmes particularly for primary school science teachers.

Part-time Certificate Course in Science Education:

The University teachers' colleges can launch more systematic programmes for the in-service education of science teachers, leading on to the award of Diplomas or certificates. The University of London Institute of Education has instituted a part-time course in the teaching of science for the teachers in service, leading on to the award of a certificate in the teaching of Science. This is in addition to the traditional advanced courses in education, leading on to Diploma in the teaching of science ~~and~~ Masters' or Doctors' Degrees with a scope for specialised narrow field of study or research in science education.

The part-time certificate course in the above institute extends

over two years for teachers in service. It provides an additional professional qualification or value to the teachers not only in the personal development of the teacher but also in his daily work with children. The course provides an opportunity to the science teachers to develop fully their skills in teaching science at the secondary stage and to relate their teaching to the scientific background of every day life. The course is so planned as:

1. to enlarge the interest and range of the teachers' scientific outlook and knowledge;
2. to introduce them to the varieties of educational techniques by which the scientific points of view may be fostered;
3. to bring them up-to-date in their knowledge and scope of the laboratory and other activities;
4. to give them some understanding of the history and philosophy of science;
5. to consider the results of experimental research in the teaching of science and
6. to review critically the work achieved in terms of students' experiences as a teacher of science.

It becomes clear that the course includes both professional and cultural aspects of the teacher education. It provides an opportunity not merely to improve their qualification as teachers of science but also enables them to acquaint themselves with the progressive aspects of the Philosophy of science education as well as with its progressive techniques and growing contents. Such a course can be organised in

many of the teachers' colleges ^{in India} for all those teachers who are living within a radius of ten miles from them. Lectures and other activities may be held on two evenings in the week in the term period. For basic courses in science the teachers may attend the university laboratories belonging to the different science departments. At the end of the course an examination may be held.

Diploma Courses in Science Education:

The Universities may institute Diploma Courses in education for science teachers who have completed their B.Ed. examination, specialising in the teaching of science. Teachers after some years of teaching experience, may be admitted for the course. The course may extend over one year for full-time students and two years for part-time students. Those who want to become full-time students and improve their qualification may be deputed by the school authorities or may be given study leave and other facilities to acquire further education. The course may include theory and practice of science education, both in its cultural and professional setting. At the end of the course there may be an examination and the results of the candidates may be declared after taking into consideration their interest, industrious nature, regularity and insight, as assessed during the course by a system of periodical assessment.

The institution of the above diploma course in science education will relieve the present congestion in the Master Degree course in education and at the same time provide a type of education to science teachers in service, which is ^{of} particularly ~~very~~ help to their particular work as science teachers.

Responsibility of the States and the Centre in the matter:-

Though the above mentioned agencies can organise different types of in-service courses for science teachers their financial resources and technical man-power as well as the sphere of influence may be limited. Therefore, the State and the Central Governments will have to undertake the responsibility of organising certain aspects of the in-service education for science teachers at their own levels. They can regularise, plan and co-ordinate the programmes of in-service education. Further, they will be able to pool both the financial resources and technical man-power for the purpose.

Reading material relating to cultural and professional aspects of the subject of science is an important medium in improving science teachers ability, skill and knowledge in teaching the subject. Therefore, both the State and the Central Governments may undertake the publication of literature related to the progress of science as well as to the progress of science teaching methodology and philosophy, both in the regional and in the all India languages. These guides, serve both as a source of inspiration, and as a source of instruction to make their work more effective in the schools.

The Work of the Professional Bodies:

There is frequent appeal from the members of the Science teaching staff as well as from others interested in science education, for the organisation of a 'National Union', of teachers similar to 'Science Masters' Association' of England. Though some organisations like the 'All India Teachers Federation', 'Associations of Engineers',

'The Andhra Medical Council'

~~Association of~~ Medical Practitioners' etc. etc., are already formed on National basis, ~~the~~ a union of Science Teachers' is yet to be organised. The Central Ministry of Education should take the lead in the matter and provide adequate financial and other assistance to the 'Union' to function and participate effectively in the work of the Nation's Science Educational Programmes.

The purpose of such an organisation should be primarily, to look after the improvement of the professional standards of science education and secondarily, to safeguard the personal interests of the science teachers. When such a national organisation is formed with its State Representatives and Branch Associations, it can contribute a good deal to the progress of science education in the country.

The National Professional Body can undertake the following aspects of in-service education of science teachers in addition to other duties connected with the improvement of science education:-

1. To Organise ~~or~~ Workshops and Seminars on various aspects of Science education, particularly on its newer and technical developments both at the National Level and at the State Level;
2. To Organise short term training courses for fresh, untrained teachers on science teaching methodology, atleast in such states where there is still the practice of recruiting untrained science teachers for the profession;
3. To arrange long or short vacation lecture course both on the cultural and the professional sides of science education;

5. To participate in the Boards and Committees to be formed at the national level by the Union Government to suggest means and methods of improving the various aspects of science education in the Country;
6. To hold annual conferences to consider the position of science teaching in the country and to suggest means and methods of improving the same,
7. To conduct survey work in respect of specific aspects of science education both at the state level and at the central level to throw light on the existing position of things and to call for nation's attention to improve the same if need be, and
8. To assist and conduct research work on problems related to science education particularly on urging problems that require investigation and suitable solution.

Local Science Teachers' Associations may also be formed either as branches of the All India Organisation or as independent Organisations. They can also organise various types of programmes to the member-teachers of the locality to foster and strengthen science education in their schools. They can be of particular help to the untrained and beginner science teachers through their programmes of demonstration lessons and discussions.

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CHAPTER XVIII

Research on Problems related to Science Education.

Although the problem of research has a long history, it is only in recent times that it has attained the status of a social importance. The delay in recognising its importance was partly due to love of old tradition ~~and partly due to the~~ ^{and partly due to the} delay in realising ^{the} effectiveness of those research studies in revolutionising our way of living. During the past fifty years the traditional beliefs are fast yielding place to rational and objective thinking. The application of principles of science to professions of every sort, has proved invariably profitable. This is true even with the profession of teaching. Naturally, research forms part and parcel of any modern profession. An Industry, an organisation or an institution will be incomplete without one or the other type of provision for experimentation and research. Therefore when we think of an educational system we have ^{also} to think of the particular provision that has been made for the advancement of the profession. It is this aspect that is an essential factor in estimating the progressive potentialities of the educational system.

Research in any field is a process of growth and aims at evolution. The method of research was systematised in the fundamental sciences from the beginning of 19th Century. But its impact on education is very recent. The first educational research report appeared in the closing days of that century; Taber in 1938, has recorded that this first educational research was post dated 1890. Sporadic research activities in the field were noticed a little later. Yet the educational research movement in the modern meaning, did not get well underway

until the second half of this century.

In the field of science education the credit of having published the first research study report goes to Gilbert H. Trarter. It was an attempt to test children's knowledge of plants and animals and thus to estimate what Nature study should be from the pupils' point of view. This research study report which appeared in 1901, was carried in the schools of Passaic in New Jersey. The first learning curve was reported by J.P. Gilbert in 1910. This was an investigation to determine the relative merits of the two methods of teaching Zoology in the secondary schools. From this time onwards, research studies were undertaken in increasingly large number and their reports began to appear both in journals and as monographs. By about 1920, reports of six learning studies and ten curricular studies were published. By about 1925, accounts of sixty studies in different fields of education were published.¹ Later, there ~~has~~^{was a} continuous, systematic and organised effort in all the progressive countries, to study various problems related to the different aspects of teaching science.

The importance of any research study lies in its desirable influence in improving the teaching practice. Many of the early research studies were sporadic and did not aim at solving the specific problems of educational practice. By about the closing days of the first quarter of this century the work of educational research was systematised so as to make each research study purposeful and direct it so as to contribute towards the progress in one or the other aspect of education. Though pure research in education is to be encouraged, the public funds that are spent over it will be a waste if it does not contribute to the effectiveness of public instruction. Hence it becomes clear that every study

undertaken in the field, must be aimed at solving a felt problem in the field of educational practice. Further, to avoid duplication of effort, time and funds proper co-ordination of research work is also essential. The research study should not merely contain a report of the result but also point out its educational implications.

The term "educational research" includes all those studies that are carried out in the field of education using the statistical technique, objective opinion-survey method and the findings of committees. On this basis certain major research studies particularly related to science education with their implications to science teaching practice, are considered in this chapter. In addition, attempts are made to locate particular areas of research where work is to be undertaken.

Major Studies in the Field of Elementary Science:

1. Interest Studies: Studies in the field of interest were the earliest to be undertaken. They were motivated with an attempt to discover the knowledge and interest, children possessed, as a basis for preparing Nature study programme.

Traffon's 'Children's Interest in Nature Materials' was the first educational research study in this field that affected the practice of teaching in the elementary schools. He undertook to discover the nature, knowledge and interests of IV, V, VI and VII grade children.¹ Another study by Libby was undertaken in 1910 and it was prompted by his desire to determine the nature's knowledge possessed by elementary school children.

After 1910 the emphasis in this line shifted from canvassing and extracting what pupils knew to discovering their interests. During the

period under reference both experimental technique and analysis of children's questions have been employed. Mann and Finley presented an animal, a physical object and a plant to a huge number of children of the III to IV grade. They studied questions asked by pupils.³

Downing and Palmer, also conducted similar studies to assess pupils' interests in nature materials. Craig⁴ and Stevenson⁵ also carried out similar experiments to assess what types of materials had greatest appeal to children, in 1927 and 1931 respectively. The above studies stimulated the interest in the child and the problems of science education. They clearly pointed out that children are more interested in animals than in plants and matters of physical science. As a result of the above verdict, curriculum makers began to include in Nature Study more of animals, less of plants and physical matters and phenomena. Slavson and Speer in their book "Science and New Education" in 1934 discorded the above tendencies in curriculum construction. Although they considered that plants and animals are valuable items of education to children they did not consider that they are valuable as science material. To quote their own words,

"Animals, including insects, are of great importance to the general development of science. Hence a scientific equipment designed to provide such development should include them as well as the materials of physical sciences....These developments which engage the mental processes of investigation and construction, which are the essentials of science to the young child, are not possible with such materials!"⁶

But Croxton does not fully agree with the above idea. He states that the child is primarily interested in himself and in his social relations;

they can comprehend, though not in its formal and abstract form, at least in its functional form. Webb in the report of his studies 'General Science instructions in the grades' concludes that -

"Real principles of Science are not assimilated by children of the fifth grade and below. Physiography and Physiology are appropriate in the sixth grade. Biology and possibly Physics can be successfully taught in the seventh grade. Physics may be assimilated in the 8th grade. But the laws and phenomena of Chemistry seem to be unsuited for any grade".⁷

Hillman tried the same experiment on 14,000 children and his study report concluded that he is in general agreement with the results of Webb's study but stated that children are unable to comprehend scientific principles.⁸ Heister, a little before, in his doctoral thesis 'Educational values of some after-school materials and activities in science' had concluded that boys who participate in curricular and extra-curricular activities excel all others in the appreciation of environmental phenomena. He further, concluded that a boy who succeeds in overcoming the difficulties, finds a new problem arising out of the old one.⁹ Later, Robertson in 1932, in his studies related to the determination of ^{the} relative merits of the two methods of teaching elementary science, has concluded that the subject matter used for the investigation with the 5th grade pupils, was purely practical.¹⁰ Haupt, in the report of his investigation "Experimental application of a Philosophy of Science teaching in an elementary school" indicated that the mental processes of interpretation, reasoning and generalisations of science are necessitated if the objectives were to teach them principles and

generalisations of science. The report also concluded that such abstract concepts are vague for the children of the lower grades and that they are better and more distinctly formed in the minds of the children of the upper grades.

Thus Haupt's study clearly suggested that the science course should be differentiated from grade to grade according to their conceptual ability.

A number of workers have expressed that principles and generalisations should not be taught for the elementary children as they are absorbed in emotional satisfaction and as the teaching of generalisation will be an unnatural environment for them to live. Their desire for emotional satisfaction may also come in the way of their ability to generalise. But this aspect is not yet studied. Till it is determined it is very difficult to provide an objective basis for making science curriculum for elementary or primary schools. Since this is a very important field of investigation, many of the research workers are engaged during the postwar days in this field. Attempts are being made through those studies to determine the nature of the science to be taught in those grades. They are in general agreement that the generalisations and principles of science may be included but should be taught not in their formal aspect but in their functional nature.

3. Studies in the field of Curriculum construction: The above investigations reviewed in connection with the interest studies, have indirectly assisted the curriculum construction. But more direct studies in the field are also carried out. The research workers in America have conducted extensive studies in the field of science

contents for elementary schools. Almost all the studies except ~~that~~ that of Paterson,^{II} have concluded that there is a wide variation in the contents. Such studies involving analysis of elementary science courses, have led to very important changes in science teaching practice. Thompson, Hillman and Craig, Strang, Cairns, Lerrigo, Bagley, Kite and Mathis are some of the Research Workers who conducted studies independently. An analysis of their results indicated that there was a positive inadequacy in the elementary school science syllabus of that time. It was clearly realised as a result of those studies that without adequate provision for elementary science in the courses of studies the subject cannot fulfil its function in education. This decisive finding affected the position of Nature study which was till then enjoyed by it in the courses of studies. All the States in America soon got busy in introducing science in their elementary schools instead of Nature study.

Another change that the above investigations brought about is the reorganisation of the training courses of under-graduate teachers. The introduction of elementary science to schools instead of Nature study, involved change in the technique of teaching and contents. So the teachers had to study the contents and methods of teaching elementary science. Unit Methods and Project Methods acquired additional interest. School science rooms were being added. Museums were being built. Thus the above investigations influenced the growth of the status of science at the elementary school level.

Craig in his study of "Certain Techniques used in developing a Course of Study in Science for the Horrace Mann Elementary School"

conducted an extensive investigation into the existing practice of curriculum making. He found confusion and irregularities and lack of consistency. So Craig set about constructing a more functional course in elementary science. He set up the following three criteria for the selection of objectives. They are: ¹²

1. Certain objectives must greatly influence the thought reaction of the individual and must have modified thinking in many fields;
2. Certain objectives should conform to information, skill and habits that go to influence health, economy and safety in private and public life;
3. Certain objectives should conform to facts principles and generalisations that help to make the natural phenomena meaningful to children;
4. Certain objectives should conform to the ability to acquaint and understand the environment, and
5. Certain objectives should conform to general outcomes of education.

Craig was able to sample out suitable contents from different science literature and arrange them gradewise so that the common objectives of science teaching could hold good for all grades. It served as a pattern for constructing syllabi and has influenced science teaching at all levels. This also served as the broad frame work of the curriculum in which the contents for the different grades are to be fixed up. His report formed the basis for the 31st Year Book of the N.S.S.E. namely 'A Programme for the Teaching of Science'. ¹³

Following the above investigation Robertson conducted elaborate investigations to determine the principles useful to realise the objectives. He finally prepared a list of 243 principles.¹⁴ Though his list could not be accepted by all workers fully, it influenced greatly the selection of materials for curriculum construction. The changes brought about by the conclusions of the above experiments induced similar changes in the courses of teacher education. A good number of new principles had to be taught by them to the elementary children in the new curricular set up. Naturally they required skill and ability to teach them. So the technique of teaching was also influenced and it is considered separately in the following paragraphs.

Further investigations in the field were directed in the same area but on a different basis. Investigators wanted to make the growth characteristics of children as the bases for fixing up the contents. This of course was in accordance with the growing movement for child-centred education. This trend was further associated with another tendency to associate science programme as part of the whole programme of pupils' development. Many of the studies conducted in this area selected the following as the characteristics of children of the elementary school:

1. Extremely active; mental or physical activities interested them;
2. Interested in train, fisherman, postman, etc;
3. Interested in immediate goals;
4. Like to have make-believe plays;
5. Try to interpret in terms of their own experiences;
6. Like to discover for themselves;

7. Enjoy a tale theme;
8. Like to express themselves in drawing or painting;
9. Interested in moving things;
10. Interested in problem solving, and
11. Interested in collecting.

The above movement to construct the courses or studies on the basis of children's growth characteristics, led to another series of investigations. ~~The studies of~~ Hanput, West Hill, Williams and others have done good work in the field. The results of ~~these~~ studies contributed for the location of suitable contents for elementary science in such a way as to assist the pupils' growth in general. Meanwhile, it was felt that the problem of arranging those contents in accordance with the pupils' way of learning them, was also important. Naturally many workers attempted to evolve suitable methods of organising contents. Studies conducted by Curtis,¹⁵ Downing, Fitzpatrick, Scarley, Finley, Nettles Heiss and others have thrown valuable light on the problem. The results of course, vary considerably in their findings with regard to the contents to be selected for a given age group. But they exhibit a remarkable agreement over the total contents of the elementary grades. Based on the studies conducted in the field, the Forty-sixth Year Book of the N.S.S.E. (Science Education for American Schools) could trace out and prepare a list of criteria for the selection of contents in science.

4. Studies in the Field of Teaching Techniques: Very few studies worth mentioning are conducted in this field of elementary science. Most of the studies conducted in this field were mainly motivated to determine the objectives and contents of the science course. But research

workers did concentrate their attention on the methods of teaching science only at the secondary school level.

Meister studied the relative values of play units and classroom teaching of science. His findings that the group taught by play units but no individual or group instruction, showed gains in knowledge almost equal to those made by the group receiving instruction involving apparatus, demonstrations, class discussions, pupils' reports, home assignment, reviews, note-book work and quizzes. Meister concluded that the extra-curricular or play group showed superior gains in many other respects including originality, inventiveness, manipulation of raw materials to usable things and the finding of new problems arising out of those already undertaken. His recommendation that boys with both the techniques of instruction will learn excellently well was welcomed by many educators and soon schools began to add a good number of activities to the science programme.

Another study worth mentioning is that of Robertson. He conducted an investigation to determine the relative merits of the two methods - the story method and the developmental discussion method. The test scores revealed little difference between the effectiveness of the two methods.

Investigations are being carried on to determine the effectiveness of radio science programmes. Carpenter in "General Science in the Rochester Schools" elaborates on the basis of evidences like examination results, reports of science activities, experimentation and note-book work that the radio method of teaching science is quite practicable and effective, particularly to children in schools without trained

teachers and laboratory equipment.¹⁶ Similar studies in the field were undertaken by Melrose¹⁷ and others. Their studies have shown that the various teaching techniques can be adapted to suit the radio programmes and the science taught thereby will be quite effective.

Research Studies in the Field of Secondary Science:

Some of the basic problems of science teaching at the secondary school level are studied in relation to its objectives, curriculum and teaching techniques. The number of those studies is very large and as such only a selected few of them and the particular way in which they influenced the teaching of Science, will be dealt with here. The publication of the 46th Year Book of Science entitled 'Science Education for American Schools', by the N.S.S.E. was greatly inspired by the major basic research studies in the field of science teaching. Wise in 1942, conducted an investigation to determine the principles of Physical Science to be taught to the secondary school children.¹⁸ Martin conducted another study to determine the relative importance of principles of biological science to general education. He determined three hundred major and two hundred and fifty-six minor principles of biological science.¹⁹ Meanwhile Keesler described Wise and Martin's work and conducted a study to determine the elements of scientific method.

The above studies indicated the contents of the subject, they also indicated the nature of the objectives of science education. So we may consider these as the foundational studies to determine both the objectives and the contents of education. A little before that, Downing had in his study already determined a list of 93 principles in general science. It is his list that prompted the work of Wise and Martin and

others. In its 46th Year Book, Science Education for American Schools, the N.S.S.E. elaborated the objectives of science education at the secondary school level. Those objectives are:²⁰

1. Functional understanding of scientific principles;
2. Development of scientific attitude, and
3. Training in the scientific skill."

Though other items were later added, the above statement of objectives provided a clear-cut goal to American science teachers at the secondary school level.

Extensive studies are also carried out in the field of curriculum and text-books. Many workers believed that grade-wise or school-wise determination of scientific principles could be done in an objective way. Attempts were made by Downing, Wise, Martin and others to determine lists of principles that could be taught. Their studies helped a great deal in the construction of curriculum. Certain lists of principles are prepared in the order of priority. This helped the organisation of curricular contents in a suitable way. While the curriculum was being constructed on the basis of objective findings a number of studies were being conducted to find out the vocabulary load and its effect on children studying science. Powers in 1925, conducted a survey to determine the type of vocabulary in high schools science text-books.²¹ In 1926 he made that the basis for constructing a list of vocabulary of scientific terms for high school students.²² Pressey Luellacole prepared a list of technical vocabulary for school subjects in general. In the field of contents and conceptual ability of children of different grades of the secondary school, a number of

experiments were conducted. The results of these and other studies helped textbook writers to write textbooks in science, keeping in view the particular topics to be dealt with as per the published lists, the pupils' particular interests and the particular vocabulary as determined by the list.

Another field of secondary science in which research studies have been extensively carried out is the teaching technique. In 1932, Stuit, ~~Dewey~~ and Englehart made a critical study of all the research studies conducted particularly to determine the relative superiority of lecture-demonstration and laboratory techniques of teaching.²³ At that time that was a problem awaiting solution. Teachers thought that lecture-demonstration and laboratory techniques are regular competitors. Some felt that one is better than the other. It was necessary to find out the relative merits of the two techniques. The results of those experiments are contradictory in nature. But the conclusions are really of interest. Instead of starting that one method is superior to the other, they upheld the individual aspects of each method. A summary of the conclusion of those ~~studies~~ is given below:-

1. Material was better retained when taught by laboratory method - (Airal)
2. The Laboratory method was superior to the lecture method (Horton)
3. Lecture method was least effective to the High School students (Wiley)
4. For permanent learning the laboratory method is perhaps slightly superior. (Wiley)
5. Laboratory method is superior to lecture demonstration method in providing knowledge and method of attack. (Knox).

Anibal, Carpenter, Nash and Philiges, Pugh, Knox and others have concluded in their reports, that the demonstration method is superior to

the laboratory method. Where as Willey and others have stated that neither of them is superior to the other. Hence it is clear that the problem is not fully decided. Further experiments may be needed. But the conclusions are helpful to science teachers. They indicate that every method is good for developing certain aspects, to teach children in certain environment, etc. Hence the above conclusions have shown that the objectives of teaching, the nature of the pupils and the laboratory facilities will largely determine the method that is to be followed.

Objective Tests:

Objective tests are the scales with which we have to measure the outcomes of instruction. For conducting investigation on various problems of science education, there is need for standardised achievement tests. This work is accomplished in all the progressive countries. Some of the tests that are in use, are listed below:¹⁴

I. Achievement Tests in Elementary Science:

1. Standard Achievement Test (Terman and others)
2. New Stanford Achievement Test (Terman and others)
3. Omnibus Achievement Test (Odell)
4. Public School Achievement Test (Orleans)
5. The Modern School Achievement Test (Gates)
6. Unit scales of attainment (Branon and others)

II. Achievement Tests in Secondary School - General Science:

1. General Science Scales - (Dvorak, August)
2. General Science Test - (Powers, S.R)
3. Glen-Gruenberg Instructional Tests in General Science -
(Glen and Gruenberg)
4. Cooperative General Science Tests - (Underhill)
5. Mastery tests in General Science - (Hunter)

III. Achievement Tests in Biology:

1. Blaisdell Instructional Tests in Biology - (Blaisdell)
2. Oakes and Powers Tests of General Biology - (Oaks & Powers)
3. Co-operative Biology Test - (Fitz Patrick)
4. Ruch Cossman Biology Test - (Ruch and Cossman)
5. Biology Tests - (Steman)

IV. Achievement Test in Secondary School - Chemistry:

1. Powers General Chemistry Test - (Powers)
2. Iowa Placement Examination (Chemistry Training) (Stoddard)
3. Iowa Placement Examination (Chemistry Aptitude) (Stoddard)
4. Mastery Tests in Chemistry - (Fowler)
5. Cooperative Chemistry Tests (Nolland Powers)

V. Achievement Tests in Secondary School - Physics:

1. Columbia Research Bureau Physics Tests (Farewell)
2. Iowa Placement Examination in Physics training (Stoddard)
3. Iowa Placement Examination in Physics Aptitude (Stoddard)
4. Final Test in High School Physics - (Hurd)
5. Instruction Tests in High School Physics (Glen and Oburn)

Other Tests in Science:

1. Tests of Laboratory Resourcefulness - (Webb)
2. Tests of Scientific Attitudes (Curtis)
3. Stanford Test of Scientific Aptitude - (Zyve)
4. Laboratory Tests in High School Chemistry - (Horton)

Some of the popular tests in use are quoted above. But there are other tests also in the field.

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Research on problems related to Science teaching in England:

In England the teachers, educators and research workers no doubt, are interested in the advancement of education through the application of objective means and methods. But as measured by the volume of published reports in journals and pamphlets one has to remark that research movement in this particular field is less active than in America. When I enquired an experienced science teacher, he told me that he could rather trust the common sense of science teachers than the statistical or other research reports. I simply remarked that such a common sense also is science, amounting to research reports. But ^{one} can observe ^{Not a good number of institutions are engaged in educational research;} the University departments of education, the various professional bodies, the Departments of psychology, the National Foundation for Educational Research, the teachers, Inspectors and other Administrators are doing research work in the field of education. But application of the verdict is not so prompt as in America. Moreover the teachers and administrators are cautious in applying the verdict of one or two stray reports. When there is overwhelming support to novel research study conclusions, the country does implement its recommendations. But what one finds in the history of English science teaching is the contributions made by the various Committees, to the Profession of Science Education in the country. Those Committees either expert committees or General committees, have made regular surveys, collected evidence from competent persons and collected adequate facts and figures before they could make any recommendations in the matter. In this sense the particular problem of science teaching have been subjected to systematic analysis and careful study. This is an accepted method of research in all matters of sociological nature. Therefore it may not be out of the way to ^{consider} the

opinions and recommendations of some of the expert committees which are as useful as the research study reports.

Inquiry

The ~~Public~~ School Commission in 1864-1869, investigated into the position of the Public School Curriculum and found that there was a general neglect of science. In their investigation it was found out that:²⁵

1. the time spent over science was inadequate; out of 128 schools examined, only 18 devoted about 1½ hours of time per week. Many of them had provided no regular time for science; 13 of them had science rooms, and
2. the higher class of people who send their children to public or Endowed Schools were not having any science education at all as science has not been given a place of importance in the school programme.

Public Schools

The Commission recommended that:²⁶

1. all boys should have some acquaintance with science;
2. all schools should devote at least one hour per week for natural science and
3. two main branches of science should be taught.

The above recommendations of the Commission were based on the regulations for the teaching of 'Naturkunde' in the Prussian Gymnasias. This Report was followed by the growth of science teaching in all the Public schools. Every institution began to construct science rooms and science laboratories. Those who had in their mind that the only thing worth learning was classical learning, now were compelled to accept that science had to be provided for in the School curriculum.

The Royal Commission in 1871-1875, investigated into the problems of improving or advancing the cause of science education in the country. The Commission collected very valuable evidences from such experienced scientists, like Rev. J.M.Wilson and others. In their report after analysing the problem before them, they indicated that:²⁷

1. Expense of building suitable laboratories and increasing the staff is sufficient to deter the governing bodies from taking any steps towards encouraging science.
2. that the existing curriculum is overcrowded and the headmasters are not prepared to introduce the subject of science.
3. the headmasters and the members of the government bodies were brought up in a classical tradition and hence were unable to realise the educational values of science.

The above analysis was the result of a clear survey of ^{the} then existed situations. The Commission never hesitated to make their findings inspite of the fact that a war had been fought in the country against science by classists. Many persons in the country still believed that 'Science was' a cold-blooded intellectual treat' having no beneficial effect on character. Like Carlyle, they thought that science is destroying the mystery of the universe. Like Blake, they felt it is making the rainbow cold. The Commission boldly expressed the above views though they were bitter pills for many contemporary dignitaries to swallow.

After careful study of the other face of the problem the Commission came to the conclusion that:²⁸

1. The value of science teaching consists not merely in the imparting of informations but in its habituating the pupil to observe and reason for himself and to check his conclusions by further observations;
2. the study of science has plenty of scope for the training of pupils' faculties and
3. elementary science is no more difficult than the elementary arithmetic and far more interesting to the young.

The above findings of the Commission are almost like the conclusions arrived at by interpreting the data collected by an objective experimental study of facts. Naturally the commission should have evolved these conclusions as a result of careful thinking on objective lines.

The Commission while investigating into the problem of finding a suitable time for introducing science in the schools, obtained valuable evidences from such scientists as Faraday, William Thomas, Datton, Ramsay of the Museum of Practical Geology and other well-known teachers of science. On the basis of those weighty evidences the Commission concluded that it may be introduced at 11th or 12th year of the pupil. Among the other recommendations of the Commission one is related to the allocation of time for science instruction. They advocated that out of 35 hours of instructional work per week, six hours may be devoted for the teaching of science.²⁹ The objective nature of this suggestion is clearly indicated by the fact that the above suggestion holds good even for to-day.

The result of the recommendations of the above Commission was that all schools began to introduce science after 11+ and allot regular



time for its instruction. It also paved the way for the organisation of teachers' demonstration of experiments and pupils' practical work.

Similarly the report of the Royal Commission (1895), the Report of the Prime Minister's Committee on Natural Science, certain aspects of the Hadow Report, Spens Report, etc., are all excellent cases of investigation into the different aspects of science teaching. Their objective recommendations have influenced science teaching in the desired direction.

Science Masters' Association now and then appoints Committees or sub-committees to investigate into various aspects of science education and the reports of the work of those Committees are certainly valuable findings that have greatly contributed for the advancement of science education in Pre-University grades of Institutions.

The University Departments of Education, the University Departments of Psychology, the two year Training Colleges, teachers and educators in the field have also conducted a good number of studies relating to different problems of science teaching. The National Foundation for Educational Research also has published reports on some studies that are directly related to science teaching.

Problems Related to Educational Research in India:

Though sporadic studies have been carried out on various problems of education in the field, many of the basic problems remain to be studied. Even though many ~~of~~ such problems have been studied by other countries they could be studied again in India in Indian environment, in Indian cultural setting and Indian socio-economic relation. Hence we shall

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not sit quiet feeling what others have done will be for us also. This confidence may be justified in the field of Physical sciences and not in the case of a social science like education.

The institution of Master's and Doctor's degrees in Education is a recent affair in the history of teacher education in India. Anybody can expect that a good lot of work in the field of educational research is to be done by the Master's and Doctor's degree students. Hence it becomes clear that the bulk of research work in the field is to be taken up in future. This is equally true with the study of the problems related to science education. However a list of problems studied in the field of science teaching is indicated below: ³⁰

1. Mukerji T.N. - Science curriculum (1949)
2. Chandawarkar M.S - An enquiry into the knowledge of children between the age of 8 and 18 in general science in Bombay Karnataka (1943)
3. Desai B.M. - A critical enquiry into the teaching of Physics and Chemistry in the Bombay Presidency (1944)
4. Gothivrekar S.R. - The Secondary School curriculum in the province of Bombay (1947)
5. Mohanram K.M. - An enquiry into books about Nature study for Indian Children - 1946.
6. Vedamaniam N. - An examination of science curriculum in Madras Secondary schools with suggestions for its recognition - 1947.
7. Mendonca Mahica - The Place and of the study of Home science in Madras Presidency -1947.
8. Vevekananda M - An enquiry into the teaching of general science in some Madras Secondary schools - 1947
9. Aiyadurai D. - A critical study of tamil textbooks in general science based on the revised syllabus for High schools in Madras - 1948

10. Raman Nair M. - A diagnostic study of 500 S.S.L.C. Answer papers in General science - 1948
11. Knobs Jacob - A critical study of the development of school curricula in Madras Presidency - 1949
12. Padmanabhan K - An investigation into Audio-visual education in Madras city schools - 1949
13. Suryanarayana murthy A.V.S. - A diagnostic study of the errors of pupils in written examination in physical science with constructive suggestions - 1949
14. Faiz Mahammed - Scientific interests of children of the lower secondary stage and their bearing on the science syllabus.
15. Vedantachari K - The new examinations and their applications to the Osmania Matriculation science course - 1941
16. Radhika Prasad - Experimental Evaluation of the relative merits of the teachers' demonstration and the pupils practical work in science teaching - 1942
17. Muniruddin - The present condition of science teaching in Balda Secondary Schools - 1945
18. Mir Ezaji Ullakhan - An Experiment for the comparison of the relative Educational values of the Supervised study method and the lecture Demonstration method in the teaching science in the schools - 1946
19. Manzoor Husain - The application science to everyday life with special reference to Higher Secondary Schools of Hyderabad City - 1947
20. Sri Rameswara Prasad - A critical survey of the teaching of Elementary Physics and Chemistry in our Secondary schools.
21. Veerappa N.S - An Investigation into the problems of science Textbooks Research in India. - 1955
22. Pandya N.P. - True-False Tests in High school Elementary Science Tests.

Science teaching in India is criticised to be stereotyped in nature. Even those teachers who came out of the training colleges are said to

relapse to this traditional way of teaching. There may be reasons for the teacher's inability to follow the modern techniques in his school. But the result is that it tells upon the instruction of the teacher. The teacher may feel that he is not able to follow more desirable techniques because of the particular administrative and organisational structure. But the emancipation of the teachers for better and progressive type of work should generally be done by their own originality, insight and expertness than by any other administrative factor.

Till very recently there was not a proper body for the co-ordination of Educational research for the whole of India. Coordination of research programme is an essential aspect of any systematic work in the field. The organisation of a separate section in the Ministry of Education for scientific and technical education and the organisation of the Central Bureau of Textbook research at the Union level have rendered the above coordination possible in the vast country. Further, as expressed by the Radhakrishna Commission the country has realised the importance of research. In the words of the Commission 'research has become a practical necessity for the continued growth of our national life. These words particularly apply to educational research. Education being the means for the growth of social life of the nation research in the field of education becomes a logical necessity'. Since Science is influencing every aspect of our social life particular attention is to be paid for those research studies which go directly to improve the theoretical and practical aspects of science education.

Though a number of problems in the field of science teaching have been studied and research reports have appeared as indicated in the above list there is need for proper planning in the field. Some of

the problems which face us are studied in other countries. Yet there is need for studying again those basic problems under Indian conditions. Hence it becomes necessary to locate the major areas of science teaching where basic studies are to be undertaken. Those problems resolve into three major areas, namely, the Philosophical, Sociological and Psychological. In other words the basic problems are to be divided into the following areas, related to:

1. Objectives of Science Education,
2. Curriculum Construction, and
3. Teaching Techniques.

Research to Determine the Objectives of Science Teaching in India:

Extensive research work has been carried out in all the progressive countries to determine the objectives of teaching science at different grades of instruction. But the results of investigations indicate that each country has arrived at different conclusion. If the investigations have upheld in America, the development of scientific attitudes and appreciations, mastery over contents and problem solving ability as the major objectives of science teaching in general, the workers in England uphold cultural, disciplinary and practical values as the major objectives of science teaching. There may be truth in saying that the spirit of the objectives of the two countries is the same though they are differently worded. Yet it makes all the difference in the selection and organisation of contents, in the approach to the subject and in the emphasis we lay on the different aspects of science instruction. But each country, it must be admitted, has evolved its own aim. Hence it becomes clear that we can neither accept the one evolved by America nor the other evolved by England. We have to evolve our own, suited to

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our national tradition, particular environment and social needs. Hence it becomes imperative that needful basic studies in this direction have to be undertaken. Since the objectives we set, control both the nature and the organisation of the contents and the approach to their treatment, it becomes evident that we have to give top-priority to those studies that directly go to define the objectives of science teaching in the different grades of instruction in our country. The objectives of teaching any subject are to be determined in close consultation with our inherited culture and the present social structure. The present social structure in India has grown so complex that its special features cannot be so easily pointed. Hence, it becomes essential to undertake various studies to analyse and understand the present social structure so that the objectives of science teaching may be studied in close relation with our past heritage. Hence, side by side with the problems related to science teaching, a good many problems which may belong to the field of educational sociology, ^{are also} ~~have~~, to be tackled.

Studies in the Field of Science Curriculum:

Side by side with the investigation on problems related to the objectives of teaching science we have to undertake studies related to the area of curriculum construction in Science. The statistical data and the historical materials gathered by research studies have to be integrated with the social background and the complex culture pattern exhibited in our present day life in determining the basic curriculum in science. Further, this should be adapted to the individual interest, ability and need. For this purpose regional surveys have to be conducted to find out the general and particular bases on which the basic curriculum is to be adapted. Particular type of standardised tests

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are also to be constructed to be used for the above purpose, like ready reckoner.

Studies in the Field of Teaching Technique:

From the field of objectives and the curriculum in science let us turn to the field of learning process. This aspect of educational practice is the most objective aspect and it is based on the findings of Psychological studies. Naturally, we have to make use of the findings of those research studies that are carried out in the different progressive countries of the world on the basic aspects of the learning process. But the particular environment in which the learning process has to operate in our schools, certainly differs. Naturally, as auxiliary studies, we have to conduct needed research in the fields of the psychological nature of our boys and girls at different age levels, the particular environment in which they have to learn, the particular approach to the teaching of the science topics. that is best suited to our boys and girls, the types of teaching aids that can be profitably used without much cost, the types of correlated activities that can be organised to provide an effective course of science experience, how best individual attention can be provided, the method of diagnosing specific weaknesses of individual pupils and the best type of remedial programme that our schools can organise for them, the technique for locating science talents and ^{the types of science} courses to foster and strengthen their talents, the types of laboratory and science rooms that we have to design for our schools, the types of laboratory exercises that can be provided to the students on the practical side, the type of records to be maintained and the method to be adopted in correcting the same are some of the auxiliary areas in which studies

are to be undertaken. Extensive but sporadic studies are no doubt, carried out in India in some of the above fields. We have to coordinate that work that is already done in the field and to chalk out carefully the work ^{that is yet} to be done in the field.

Construction and Standardisation of Measuring Scales:

Standard Tests are available to measure the achievement of children in science. Tests are also constructed in some of the regional languages of India. But such standardised tests are not available for all regions. Within the limits imposed by language, curricula of the different States the work of constructing and standardising these tests should be completed at the earliest time since they are essential for investigation of the rest of the problems in the field of science education.

Other standardised ^d tests that are to be constructed are the tests to measure scientific attitude, diagnostic tests, aptitude tests, tests of science interest and tests of science personality. These tests again, are to be constructed in the different regional languages after taking into consideration the particular culture pattern of the region.

Research in the Field of Science Textbooks:

Textbooks form the major materials of instruction in any subject. Naturally it becomes imperative on the part of the schools to procure the most suitable types of science textbooks. In most of the States the State Departments of Education prescribe the science textbooks with the assistance of expert Committees. While doing so it will be difficult to decide which book is best suited without proper criteria.

for evaluating the same. Further, the principles to be observed in preparing the science textbooks are to be definitely ascertained. In a number of schools where reference and other books are not available, textbook will have to serve as the only guide both to the pupils and to the teacher. Therefore attempts should be made to evolve good textbooks in science.

Different authors follow different principles in preparing the textbooks. This is mainly because of the absence of objective findings in the field. No doubt, extensive research has been carried out in other countries in the field of textbook ~~research~~. Basing on those studies some work has been done in India too. But the books are to be written for Indian children, to learn in Indian cultural environment. Even the language differs. Every state has to get books written in ~~the~~ ^{its} particular regional language. Science being a new subject to our culture many of the technical terms are to be coined though some classical terms may be used as such. Further, the approach to the different topics, the organisation of matter, the display of matter etc., are all features which are to be based on the nature of the learning process. It becomes clear that textbook writing is a technical job to be performed in close conformity with the objective findings of the related studies in educational research on the one hand and with the correct and up-to-date position of the subject matter on the other.

Science textbooks are being written by experts in America~~X~~. Usually the textbooks are written by a team of experts. The team may consist of a subject expert, a psychologist, a language expert and an artist. Each one will look~~after~~ the particular feature of the book.

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Thereby the books prepared with such care and by such technical experts will greatly help the pupils in their learning process. The following series of science textbooks which are commonly used in America can be illustrated for the above type:

1. Path way of Science
2. A Survey of Science
3. New Plan~~ned~~ Texts
4. New World of Science
5. The Basic Science Education.

Problems in the Field of Science Textbook Research:

Most of our science books are being written keeping the English science texts as models. England has realised that many of the science textbooks used in schools, are even today, as academic as they used to be during the first quarter of this century. Attempts are being made to prepare books to suit the psychological needs of the children. This is exhibited by the fact that ~~a number of~~ ^{American} general science books are being adapted to English conditions as they are best suited for children. But to us in India those discarded types of science textbooks are serving as models. This is mainly because in the absence of adequate research findings in the field, the authors will have to depend upon already written science books as models. Usually we used to get the science textbooks written for English children very easily, because of our long contact with England. Those who could realise that many of those textbooks are more academic in nature, have attempted to evolve textbooks in their own way for our children. This has led to the adoption of different approaches, many a time, one apposing the other. In this connection a recent survey was conducted by me to assess the problems

that face the textbook writers. Thirtynine problems could be traced out. A list of those problems which are to be studied is reproduced below from the author's original report on the above study ~~report~~, namely, "An Investigation into the problems of Science textbook Research in India".

For purpose of convenience the above problems are divided into six major areas as indicated below: ³¹

1. PROBLEMS RELATED TO THE EDUCATIONAL OBJECTIVES OF SCIENCE TEACHING.

1. Determination of the relative importance of the following accepted educational objectives of science instruction at the Elementary and Secondary school levels:

- a) Functional understanding of the scientific principles,
- b) Development of scientific attitude or skill in scientific method,
- c) An appreciation of the implication of science for the industrial civilisation of the time,

2. In accordance with the findings of the above study,

- a) Determination of the space to be allotted to each of the above three aspects,
- b) Determination of the nature of approach to the various topics,
- c) Determination of the type of application and the point of emphasis, and
- d) Determination of the types of exercises to be set at the end of the topics.

II. PROBLEMS RELATED TO THE COURSE CONTENTS AND PLAN OF APPROACH

1. Determination of the relative superiority of the integrated

and the separate treatment of the three main branches of science with regard to pupils' interests and achievement in the subject at various grades of institutions.

2. Determination of the relative superiority of the following types of textbooks:

a) Fusion-textbooks each dealing with all the branches of science and each of such books intended for the different classes of the secondary school,

b) Separate textbooks in each of the three branches of science and each intended for all the classes of the secondary school.

3. Determination of the major and the minor principles in each of the three branches of science for various grades of the elementary and the secondary schools.

4. Determination of the amount of space to be used for the following features in the books intended for the elementary and secondary schools:

a) Definitions, principles and formulae,

b) Descriptions of apparatus, experiments and structural details,

c) Application of principles to problems of life,

d) Biographical information of scientists, and

e) Industrial and social implications.

5. Determination of the list of topics on the basis of pupils' interests for various age levels.

6. Determination of a list of topics in the different branches of science for general education.

7. Determination of the relation between the pupils' interest in the book and the number of application to life problems, made in the book

8. Determination of the relation between the provision, at the end

of the topic in the book for after-school activities and the interest shown by the pupils in the scientific hobbies.

9. Determination of the relation between the amount of space allotted for the biographical aspect of scientists and the interest of the pupils in the subject.

10. Determination of the correlation between indices and cross - references at the end of the book and the students achievement in the subject.

III. PROBLEMS RELATED TO THE METHODS OF TREATMENT

1. Determination of the relative effectiveness of the following techniques of treating the topics for elementary and secondary schools:

- a) Method of elaboration or the essay type,
- b) Method of experimental approach,
- c) Mixed method employing a and b, and
- d) Problem or project approach.

2. Determination of the relative magnitude of inductive and deductive approach to be adopted in the books intended for the elementary and the secondary schools.

3. Determination of the relative superiority of the following methods of treating the topics for various age levels:

- a) Topical treatment,
- b) Academic treatment, and
- c) Psychological treatment.

4. Determination of the relative effectiveness of the following types of introduction to the topics with regard to various age levels:

- a) Subject introduction,
- b) Humanistic introduction, and
- c) Social introduction.

5. Determination of the relation between the correlation of studies in the different branches of science and the pupils' achievement in the subject as a whole.

6. Determination of the correlation between the ability to recall and the presence of a summary at the end of the chapter.

7. Determination of the relative superiority of the following types of arranging the facts with regard to comprehension:

a) Tabulation method,

b) Paragraph method.

8. Investigation into the effectiveness or otherwise, of raising problems during the course of the development of the topic in the book.

9. Determination of the relative effectiveness of the different types of exercises given at the end of the chapter with regard to pupils' ability to apply book knowledge to problems of life.

IV. PROBLEMS RELATED TO LANGUAGE, STYLE, VOCABULARY LOAD, TECHNICAL TERMS, Etc.

1. Determination of the minimum load of facts to permit healthy comprehension at various age levels.

2. Fixing up of length of sentences suitable for easy comprehension at various age levels.

3. Standardisation of samples of language to be used in books intended for various age groups for purpose of:

a) Definitions,

b) Description of experiments,

c) Inference, and

d) Applying principles to problems.

4. Conducting experiments to investigate into the effect of

vocabulary load with regard to:

- a) Comprehension,
- b) Interest shown in the subject.

5. Preparation of standardised word-lists, both in Hindi and in the various regional languages for using in the textbooks for various ~~grs~~ grades, following Thorndike's word-list.

6. Preparation of standardised list of technical terms to be used at various age levels.

7. Determination of the relative suitability of using:

- a) English technical terms,
- b) Hindi technical terms, and
- c) Regional language technical terms.

8. Fixing up of the minimum frequency of technical terms to make them current at various age levels.

9. Preparation of a list of wrong synonyms and non-scientific words generally used in science books.

10. Determination of the effect of wrong synonyms and non-scientific words used in the book on:

- a) Comprehension,
- b) Development of scientific attitude, and
- c) Development of skill in scientific method.

W. PROBLEMS RELATED TO ILLUSTRATIONS.

1. Determination of the size of illustrations congenial to pupils' interests and ability to understand at different age levels.

2. Fixing up of a healthy proportion of illustrations to written material for various age levels.

3. Determination of the relative superiority of the following

types of illustrations for various topics, for various age levels:

- a) Line sketches,
- b) Diagrams,
- c) Shaded figures and
- d) Photographic reproductions.

4. Determination of the correlation between the number of illustrations and the pupils' achievement at various age levels.

5. Investigation into the problems of effective display of illustrations.

VI. PROBLEMS RELATED TO EVALUATION AND SELECTION OF TEXTBOOKS IN SCIENCE.

1. Determination of the relative superiority of books written by a committee and the books written by an individual.

2. An Investigation into the problems of getting science books written by a team of experts, consisting of:

- a) Subject expert,
- b) Language expert, and
- c) Artist and Photographer.

3. To evolve an objective scale to assist in the selection of textbooks, taking the following features into considerations:

- a) Contents,
- b) Method of treatment and planning,
- c) Experiments,
- d) Illustrations,
- e) Application of principles to problems of life,
- f) Questions and exercises,
- g) Language, style, vocabulary load and the use of technical terms,
- h) Cultural and social aspects, and
- i) Mechanical features.

The above attempt to locate the areas in which research studies are to be undertaken in the field of science textbook research does not claim to be either complete or final. When similar attempts are made more problems may be located. As time advances fresh problems may also creep in. Hence it is needless to state that there is need for continuous investigation into the problems. Such an effort to improve textbooks by providing objective findings is as much a necessity as it is in the case of curriculum planning. That is how we can make our textbooks keep abreast of time.

The Organisation of Research studies in the Field of Science Teaching:

Though the University Departments of Psychology may contribute valuable Research contributions to the Profession of education, it is the responsibility of the profession itself to organise, plan and co-ordinate research studies in the field of education. The University Departments of Education and other Post-Graduate Teachers' Colleges will have to lead the Professional workers in this direction. They have to carry on research on some of the basic problems facing the teachers. They have to guide teachers who are carrying research work with technical assistance. Similarly the State Department of Education in every State will have to organise a State Bureau of Educational Research. The Central Ministry of Education will have to maintain research institutions to study problems related to the different fields of education. The Council of Teachers' Education or any other National Organisation of Teachers may also organise research work on problems facing the teacher. Hence it becomes clear that a good number of institutions or organisations

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will have to share the responsibility in the great task. The Central Ministry of Education with its institutions and departments will have to undertake the responsibility of planning and coordinating the research work that is being undertaken by the different persons, institutions and organisations in the country. This is essential to ensure that duplication of effort or neglecting the study of pressing problems are avoided. Further, neither the state nor the other agencies that may take up problems for study may be able to get adequate financial resources. It is the responsibility of the Centre to provide adequate financial assistance to all those Organisations and persons that are engaged in research work, since the findings of those research studies go to improve the education of the nation as a whole.

In recent years, the Central Ministry of Education is evincing keen interest in promoting the cause of education through its liberal financial assistance for research work to the University Departments of Education, Teachers' Colleges, Research Bureaus attached to the State Department of Education and other Organisations interested in research work on problems of education.

So far as problems in science teaching are concerned, there are no separate Organisations to conduct research work. As part of the Central Bureau of Textbook Research however, a section for science has been opened. Except for this provision there is no other organisation in India exclusively meant for tackling problems in the field of science teaching. No doubt studies in the field of science teaching form part of educational research in general. But the nature of the problems, the order of their priority, the interpretation and application of the

research findings are best known to science teachers and science educators. Moreover, the subject is rapidly growing and frequent and new problems that face the teacher are to be studied. The results of these studies should be interpreted and applied to the field without delay. Hence it becomes clear that there are special claims of the subject to have a separate Central Organisation to plan and coordinate the research studies that are being undertaken by different organisations and persons in the country are justified.

The bulk of educational research in India as in other countries is being done by the post-graduate students of education studying for their Master's or Doctor's degree examinations. Research fellows employed for the very purpose also carry out substantial work in the field. The above post-graduate Degrees in the Indian Universities are instituted comparatively recently and as such not much work is done in the field. If proper care is bestowed in selecting topics for the students of post-graduate research work, the training colleges can do a good lot to help the nation's educational research programme. But, generally, this aspect of the ^{work of the} teachers' Colleges is rarely satisfactory. As expressed by Srimathi Hansaben Mehta, Vice-Chancellor of the University of Baroda, in her address to the First Conference ~~of the All India Conference~~ of Teachers' Colleges, 'Ideal Training Colleges must be research centres which should be continuously striving to find out better and better solutions to our problems. No doubt every one is not capable of doing research work. But why can we not demand that those who have both the ability and the bent of mind, should be selected for such important post-graduate institutions?'

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Training of Research Personnel:

The M.Ed. Course as observed by the Radhakrishna Commission in their report on University Education, should be for guiding the beginners in the Techniques of Educational Research even if the results are necessarily small and scrappy.³¹ At present this is the only organised course for educational workers to get trained in the field of research. Naturally all those who intend doing some research work in their school cannot go for the M.Ed. course. Therefore, there is need for organising some courses for the benefit of such teachers who could like to take up research work wherever they are

These courses may be organised either in the Teachers' Colleges or in the Colleges of Technology. The course must be so forged as to provide a grounding in the statistical methods of dealing with educational problems, interpreting the results and even drawing up implications of the findings. The course should also include some aspects of sociometry and experimental sociology. With regard to the training of research workers in the field of science teaching, attempts must be made to provide opportunities to the trainees for knowing the types of problems that face the science teachers. This naturally, necessitates that the trainees should have taught science for a sufficient length of time, before they actually seek admission to this course of training of research workers.

Research workers should possess such qualities which are essential for the study of both humanities and sciences. Sympathetic creative thinking as well as the ability to handle objective data by quantitative methods, are also essential.

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By a perusal of the excellent summary of the research work done ^{published} in India, by the Indian Journal of Educational ^{Research} ~~one~~ will understand that we have enough man-power capable of tackling our problems in the field of education. But it also indicates that there is perfect lack of co-ordination and organisation. Further we notice that the bulk of the research work has been carried out in the field of History, Languages and Mathematics. Very few studies are devoted, particularly to the study of problems facing the science teachers. Though some of the professors of the University Departments of Education have done some high quality work, it suffers from lack of coordination and proper planning among the Universities themselves. The country has set out to forge her fate through a process of rapid industrialisation. This course demands a well organised system of science education at all levels. But science is a new subject to us. We have to solve many problems in the field. Both the Centre and ^{the} States will have to tackle those problems by a planned and well coordinated programme. The University Departments of Education, University Departments of Psychology, the State Departments of Education, the Central Research Organisations and the other institutions connected with educational research will have to cooperate in this stupendous work.

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CHAPTER XL.

SCIENCE IN SOCIAL EDUCATION.

The progress of education in any country depends largely upon the willing co-operation and the intelligent participation of the public. Hence it becomes clear on the part of the educational administrators, that they should try to enlist the cooperation and seek the participation of the public. This is all the more necessary as education today, does not remain as before, the mere concern of the department# of education and the agencies of education. Rather, it has grown into a process of partnership between the education department and agencies of education on the one hand, and the public on the other. This principle applies to science education also. It further implies that any system of public instruction should also make provision for the education of the adults. Then only there will be an intelligent and enlightened public participation in education.

In a country like India where there is no provision for universal compulsory education it is natural to expect that a large majority of people will be illiterates. For them there is need for a regular programme of adult education, the chief aim of which is to provide opportunities, for those who could not go to school in their younger days, to become literates. A good number of people will have discontinued their studies after the primary classes and as such, the education they have received will be quite inadequate to live as successful individuals. Hence there is need for a programme of further education to those adults who could not have adequate schooling in their early age. If the former is intended to liquidate illiteracy the latter is intended to provide

to the public, opportunities of further education by which they can be enabled to participate more effectively in the social, economic and political life of the country.

Adult education movement, after the first world war took the form of spreading literacy among the illiterate people. The experience of the workers in the field of literacy work, revealed that the adults are not attracted by mere literacy work and that literacy is only one of the media of adult instruction. Therefore adult education acquired a wider connotation. Meanwhile, the advent of democracy after the emergence of freedom, demanded for the adults some sort of civic education and training, essential for democratic group life. In addition, the progressive industrialisation of the country demands on the one hand workers, who ^{can} appreciate the role of science in our national economy contributing to the individual and social efficiency. Consequent to the effort of the nation to put her economy on an industrial footing the common man will have plenty of leisure to utilise. Many of the recreational programmes are pervaded by the effect of science. This necessitates that the adults should have some knowledge of science and how it is serving mankind. Added to these, the present society, culture and civilisation are ^{shaped} ~~named~~ by science. That again demands on the part of the adults to know some facts, develop some attitudes and appreciations and acquire some habits and skill which are scientific. As a result of realising these newer demands the old literacy work has now grown into a programme of social education. The Ministry of Education in its pamphlet (No.58) has defined social education as 'a course of study directed towards the production of consciousness of citizenship among the people and promotion of social solidarity among them. It has three aspects, namely, the introduction of literacy among ^{the} grown-up

illiterates, the production of an educated mind in the masses in the absence of literary education, and the inculcation of a lively sense of rights and duties of citizenship, both as individuals and as members of a powerful nation.' To this, we may add a fourth aspect namely, the imparting of the minimum essentials of scientific information, skill, appreciations and attitudes, required for every individual to lead a successful life in an industrial society, pervaded by the impact of science. Hence, it becomes clear that any scheme of social education should provide for some amount of science instruction though not in its systematic or formal nature.

Social Education has to be planned not merely for the education of the illiterate adults but also for the literate adults who could not have adequate amount of instruction in their early age and for those who though educated, would like to further their knowledge, interests and skill. Hence while planning for the social education programme the nature of the particular needs of the masses will have to be taken into account. It is inadequate to include merely some aspects of literary and cultural items as it used to be in the early period of adult education. This was probably found necessary when workers in the field placed their whole confidence on literacy as the only medium of instruction. The newly made literates were probably unable to understand instructions relating to civic, industrial and scientific aspects of life. Today it is an established fact that other media of instruction, like films, radio and many audiovisual means can be equally, if not more, effective, in imparting instruction. Hence, whether it is for the newly made literates or ^{for} the other adults who want to further their education, civic and scientific aspects of living can be included. In such

progressive countries like U.S.A., U.K., and U.S.S.R. adult education has taken the form of social education. Illiteracy is not found there since compulsory elementary education is being enforced universally in those countries since the later part of the last century or atleast from the beginning of this century. Therefore social education in those countries takes the form of further education to those who are employed. Those who discontinue their education at their fifteenth year of age do require educational facilities either to improve their general knowledge or skill ~~and~~^{or} to improve their trade. Even in the case of those who could study further, social education cannot be unnecessary. No doubt, they are capable of studying for themselves, the newer developments in social, economic, political, industrial and technical fields. Yet they can be better benefitted by an organised course of social education suited to their level of maturity and scholarship. In their case the other newer media of instruction will supplement the literary medium of instruction. In India, where compulsory elementary education is yet to be introduced in the majority of states, in addition to the above two types of adult education programmes, there is need for organising a third type for those who are just now made literates. So social education in India has to be provided at three different levels as indicated below:

1. A basic programme for the newly made literate adults;
2. An advanced course of further education for those who had to discontinue after some education; and
3. A course of education based on the particular interests and needs of the enlightened public engaged in the pursuit of the courses of studies of their choice.

The remaining part of this chapter is devoted to a consideration of the contents, techniques and organisation of science education as part of the social education programme.

Science Contents for Social Education:

1. The Basic Programme: The aim of science education for the newly made literates differs from the aims of those of the other two categories of social education. The newly made literates generally represent the culturally backward strata of the society and many a time, are victims of superstitions and blind beliefs. They must be reeducated through science so as to develop a rational outlook. Similarly, they must be informed of the wonders that scientists have done in improving the affairs of man. They must be educated to appreciate science as a boon to mankind in relieving many of its difficulties. The modern means of transport and communications will also be interesting and useful to them. They must also be made to understand that many of the diseases are due to carelessness, ignorance and bad habits on the part of the people. Thus they should be led to realise the importance of clean and healthy habits both in their interest and in the interest of those who are related to them. This must lead them on to realise their responsibility in maintaining public health as a part of their duty to society. They must know about the food value, ventilation, disposal of refuse, drainage and the futility of undue emphasis on certain rituals ~~though they~~ are not sound from the point of view of the laws of personal and social health. Provision may also be made to make them learn or get training in the art of healthy living

and of keeping themselves and their surroundings clean. In one word, the contents should include all those aspects of science education both theoretical and practical, that go to make the life of the ignorant millions more pleasant, profitable, useful and enjoyable.

This course can be organised along with literacy education by the State Organisation for adult or social education in particular, and ^{by} the various workers associations in general. Nearly three crores of the population come under this scheme. This recently organised Community Project Centres can tackle this problem more effectively.

In the early stage of the course until the adults acquire some mastery over literacy, other media of instruction like radio, gramophones, filmshows, demonstrations and exhibitions can be employed. Both as a followup to the literacy course and as furthering of science education, suitable reading literature like, science bulletins, journals and talks can be employed. In still advanced stage, books and periodicals of scientific interest may also be used. Visits to factories and other places where the impact of science is apparent, can also be organised.

2. The Advanced Programme: This course is intended for those adults who had their education upto their 11th year or a little longer. At present there are about 45,00,000 pupils who discontinue at their 11th year in every school year. At the same time every year, another ten lakhs of pupils discontinue their studies at their 14th year of age. Hence it becomes clear that this class of adults who discontinue their studies either after their primary education or in the middle

of their secondary school, will be in a substantially large number in the country, distributed mostly, in the rural areas and to some extent, in the urban areas.

Most of them had little or no science in their school days and as such, they are practically illiterates so far as science education is concerned. It is also likely that the little literacy which they had acquired in the schools might have been lost in the majority of cases where little or no opportunity was provided to exercise that tool. Hence they will be practically in the same level as the newly made-literates for purpose of science instruction. The course contents to them may be the same as indicated for the basic course but with greater emphasis on the literary approach to study.

The Science Course for this category of Social Education, may include application of science to some of the modern problems like the transport, communication, Mechanisation of Agriculture, health and sanitation, food and shelter. The control of diseases and raising of the living standard through the application of science may also be included. This course may take the form of 'Popular Science', without including formal or systematic aspects of the science.

The Science Course for the Interested and Enlightened Public:

This course of science is intended for all those who had a good general education ~~and~~ ^{and who} in their early age, want to continue their interest in science which they had already developed in their student days, either as a result of specialisation in the subject or as a hobby of interest. In the science course intended for this category of adults,

topics like energy and its application, progress in technological field, mechanised agriculture and industry, newer developments in Medical practice, radio and space exploration, food and population, space travel, effect of radio activity, effect of the impact of science on social structure etc., may be included. The contents may be spread over different periods of the year according to a regular plan. This course must include new applications of science in the different fields of human activities and the ways in which those developments are to influence human civilisation. It is also necessary to include some topics of sociological and philosophic aspects of science at this level.

Technique to be Employed:

The adults though illiterate, are not the same as children in their mental make-up, particularly in their ability to conceive things. This naturally demands the employment of a technique that is different from that which is employed for teaching the children. The adults have a good number of concepts already formed and as such the understanding of what is taught can be highly facilitated. Further, their attitudes and appreciations have reached maturity in their own way and therefore they cannot be treated as children. They have to be taught taking them as partners in the process. Though they cannot use literacy as an effective tool in the beginning, they can understand what is told and what is demonstrated since they have gained connected experiences by different ways. Hence talks, demonstration of experiments, pictorial representations and films can form effective ways ^{and means} of teaching them. Some times formalities of teaching may have to be set aside and

programmes may have to take the form of improved^{informed} talks and demonstrations. Such a flexibility is essential to enlist their full and free participation in the learning process. As their literary ability increases, suitably written books may be used. Library facility will greatly help the spread of social education. Stress should be laid at all stages on the application of principles to familiar problems.

At the advanced level lectures and demonstrations may be employed as means of imparting social education. As far as possible analogies should be used to make scientific facts and principles clear. Practical implications of the topics of treatment may be clearly drawn so that they can understand and appreciate science as a subject of practical implications for improving their ways of living.

Science education for those who are intending to pursue their interest in the subject may be organised in the form of short or long term vacation courses. The lecture-demonstration method may be followed as an effective technique of instruction. Economic and sociological implications of the topics may be clearly indicated so that they may realise the impact of science on the social and economic life of the nation.

Organisation of Science Courses:-

No doubt, the organisation of science education at the social education level should be entrusted to those institutions and agencies that are connected with social education. In England the Workers' Education Society, the Extramural Section of the Universities and other

social and professional organisations generally have taken up the responsibility of providing social education to the people. Special Science courses of an advanced nature are organised by the Ministry of Education in co-operation with the University Departments of Science. The Science Masters' Association and other Associations devoted to the cause of science ~~and~~ education, will also organise lectures and demonstration courses in science for the benefit of the adults. Sometimes short or long term lecture courses are organised at different places of the country with residential provision. Certain Institutions like the Royal Society of Science and the Institute of Science also organise lectures on Science topics of current interest or on topics that involve newer developments. As part of such vocational science courses excursions are organised to ~~Museums~~, laboratories and to other fields and places of scientific interest. The British Broadcasting Corporation has a well planned programme in science education for the country. This of course takes the form of the three levels of science education as already indicated. The local education authorities also provide for science education as part of adult education through the different types of day and evening schools, institutes of various kinds and youth centres. They also assist those institutions that are maintained by voluntary agencies with liberal grants. The proposed County Colleges for the education of youths after they discontinue~~d~~ their studies are yet to be organised. When a net work of County Colleges is organised all over the country, more effective provision for further education of the adults will be ensured. This provides both vocational, cultural and recreational programmes to the youths. Science topics with experimental demonstrations, wherever

possible, are included in large number in the general and cultural educational programmes. The applications of Science however, will apparently dominate in all those science programmes.

In India every State has one or the other type of organisation for adult or social education. It may be directly under the control of the State Department of education or the responsibility may be entrusted to some voluntary agency. The adult education movement started in the first or second decade of this century, has gradually grown into a purposeful drive into what is now called a social education. In the early period the State Departments of Education were organising what were known as night schools mainly intended to wipe out illiteracy among the grown up people. When the work expanded, the responsibility was entrusted to independent organisations or voluntary agencies. They used to organise literacy Centres for teaching the adults the three R's. Such centres did not become popular since the adults did not show interest in mere literacy work. So recreational and cultural activities were added to the programme. Science, scientific instruments, science films and science demonstrations can equally attract the adults for participating in the programme. This aspect is yet to be attempted. No doubt, in some states simple books on the topic of science are being brought out for the newly made-litrates. Other organisations that are doing social education work in India are:

1. The Workers Literacy organisations,
2. The Indian Adult Education Association,
3. The Community Project Centres,
4. Scout and Red-cross Associations,

5. Sevadal, Gandhi Vichar Parishath, etc.,
6. Gokhale Institutes,
7. State Departments of Public Health, etc,
8. Rotary Club, Ladies Clubs, etc.,
9. A variety of social and cultural institutions recognised or unrecognised by the Government,
10. The University Extension Service Departments,
11. Radio, and
12. Newspapers and Periodicals.

This list indicates that there are ^{different types of} ~~various~~ organisations engaged in the field of social or adult education, each doing work in its own way. There is need for bringing about proper co-ordination and articulation in their work. Only a few of them include science in their programme. The rest of them will have only classics, like Ramayana, Bharatha etc., as the main source of their programme. Even in the case of organised instructions, ~~the~~ science is generally neglected in their programmes. However efforts are being made to include some topics of science for the different grades of social education programmes. Even ~~the~~ the recently started Rural Colleges that give liberal education to adults ^{they} do not provide adequate amount of science education. They devote a greater part of the time for recreational and emotional activities. Even in the University Extension Lecture Programme, science is not represented in a desirable proportion.

The Central Advisory Board of Education has, as its wing, an Adult Education Committee. This Committee has to realise the importance of science to ^{the} modern life of people, whether literates or illiterates. The Committee may try to influence all those organisations engaged in



social or adult education work to include topics of science and even to provide activities connected with science programmes.

Most of our cultural Associations cited above, aided or not by the State, take up the work of propagating some aspects of our ancient traditions as if nothing ~~else~~ is essential for the modern life. It is high time to realise that the public funds shall not be spent only over such items which have doubtful value to the present life in its modern texture. It shall be the responsibility of the State Government to insist that the grant given to private or public agencies should be utilised for the enrichment of modern life in its modern texture. Atleast, such grants should not be permitted to be used for the propagation of activities and ideals that are definitely antagonistic to rational aspect of thinking which is the essence of science teaching in our schools. If provision were to exist for the creation of such an antagonistic atmosphere in the social texture of the adult life it will wield a negative influence on the effort of the schools to develop in the minds of the youngsters an understanding and an appreciation of the spirit and the outlook of science. Hence it becomes necessary on the part of all those who are interested in the outcome of an effective science programme in the schools to see that no negative effect outside the school, in whatever form it may be, is ~~allowed~~ officially encouraged either by the State or by the Community. It must be clearly understood that this does not mean that we should prevent the appreciation of the Truth, Beauty and Power ^{through the humanities.} Rather, it merely attempts to keep the human mind free from ^{ignorance}, superstitions, dogmatic assertions and such other attitudes and outlooks which ^{are} definitely ~~not~~.

considered to be the tragic flaws in a modern sociological texture.

At present science instruction in our country is provided mainly in schools and Colleges through the formal teaching of the subject. But they are not the only institutions that are moulding the character and personality of our children. There are hundreds of other agencies that are probably wielding a more powerful influence in shaping the character and personality of our youngsters. Most of them are traditional in outlook and devoted to the propagation of ideals and activities that are far from ^{being} realistic. Though they do not directly undertake the work of imparting the systematic aspect of any curricular subject, they do influence the development of the personality of the youths with regard to certain attitudes, certain ideals, certain outlooks and certain ways of thinking, feeling and acting. Such outcomes of the educative influence of those social agencies and institutions ^{many a time} are opposed to the very spirit of science instruction in schools and colleges. Therefore the activities of such a type are to be considered as a setback and a challenge to our educational programme intended to prepare our children and youths to the life of a modern scientific society. Therefore, it becomes clear, that for the success of the science instruction in our schools and colleges, a suitable social background in the mental set-up of the adults and their institutions becomes quite necessary. Though there are some social institutions that ^{are} doing work in the realistic direction, there are yet a good number of institutions with their unrealistic and traditional programmes. They do oppose the spirit of science even though they never hesitate to use the benefits of science for their activities!

Any attempt to control their activities such as to contribute for the growth of realism and rational thinking in the society, will surely count the indignation of many people and institutions. The only method of achieving such a change in the desired direction, is the reeducation of the minds of the adult individuals by ^{or} well-planned programme of social education with science as a dominant subject.

Towards a New Social Order:

The advent of science into our social education scheme will gradually change the ways of our living, thus contributing to the evolution of a new order of society. The individuals in such a society will be free from superstitions and other blind beliefs; they will base their conclusions on material evidences; they will think and act in an objective way; they will respect the 'cause and effect theory' in their every day life; they will exhibit objectivity in their outlook, attitudes and appreciations; ^{they} will view and weigh things without bias of any sort; they will always keep their mind open and be ready to revise their conclusions; they will have confidence with conviction in the strengthening of national economy through the application of the principles of science to the art of industry, and above all, they will be lovers of Truth, Beauty and Power as ^{the} highest ~~of~~ ideals ~~in~~ in life.

CHAPTER XX

Science in the Universities and other Higher Education Institutions.

The purpose of education is to ensure that the cultural heritage of the race is handed over from generation to generation. In other words, education has to act as a means of transmitting the cultural wealth of the race from generation to generation. This transmission is not a mechanical process. The individuals will have to acquaint themselves with the cultural wealth; then, they have to interpret the same and try to improve it with their original contributions before the inherited wealth of culture is handed over to the next generation. This tripple responsibility of education necessitates all its manifold organisations regarding its objectives, nature of contents and the techniques of instruction. Schools are generally, ^{the first aspect of the education, at the University level, the second and third categories of objectives.} concerned with the second and third categories of objectives. Though these three objectives are of three distinct categories, contributing for the differentiation of institutional organisation, selection of contents and nature of instruction, the entire scheme naturally forms one continuous process of education. Hence it becomes necessary to consider science education at the University and other higher education level to some extent in continuation with that of the school science programme.

If the main work of the schools is to assist the individuals to acquaint themselves with the wealth of human experience that of the Universities is to assist them to interpret and improve the same. If

If we were to evolve a general aim of University education on this basis we can say that the Universities have to assist the individuals to acquaint themselves with the racial culture and enable them to contribute to its progress, thereby also assisting them to develop their personality. This aspect is more clearly expressed by the University Education Commission of 1948 in their report published in 1949. According to the above report the aims and objectives of University teaching are:¹

1. Transmission of the intellectual and ethical heritage of humanity to the Young;
2. enrichment of this heritage and extension of the boundaries of knowledge ~~and~~
3. development of personality.

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The University education has to arouse the interest of the pupils in the field of the study which they have ^{selected.} ~~chosen.~~ In addition to the work of providing factual information it has to stimulate their spirit of enquiry and of criticism thus contributing to the growth of the pupils' personality through the acquisition of the habit of independent and unbiassed judgement and the ability to discriminate between adequate and inadequate, relevant and irrelevant data, and the steadiness in avoiding the extremes of haste and indecision in arriving at conclusion

The University provides comparative freedom to the undergraduates who are generally sufficiently mature for the particular kind of instruction that is provided. The nature of the work of the Universities should be, as per the report of the Calcutta University Commission of 1919, ^{such as} to enlighten and practice the conscience, both moral

and intellectual. This conscience looks in close relation in life to three interrelated types of existence, the natural, social and spiritual. The contents of instruction can be classified under these three heads - natural, social and spiritual. It is with the natural aspect that we are concerned here. Natural or experimental sciences as well as technological courses come under this group of instruction. No doubt, every pupil should possess a knowledge of the physical world in which he lives. But this knowledge is made up of a number of branches. Every one cannot specialise in every one of those branches. But every student will have to know something about each of those branches of science while specialising in one or two of them. This principle should form the fundamental basis for organising science education at the undergraduate level. Whereas at the postgraduate level the student should be expected to study some aspect of his subject with a view to do some original research work. The science courses at the University level may be of different types depending upon the particular purpose with which they are instituted. There may be a science course intended for the non-science specialists; there may be a science course for broad specialisation and there may be another science course for narrow specialisation. It is essential to know the particular purpose or purposes which each of the above three types of Science Courses is expected to serve.

I. Science for General Education: This course is intended for those undergraduate students who are not specialising in science but in one or the other aspects of humanities. A course of science including topics from various branches of science will form the IV part in some of the Universities. In the three year degree course the general

science will be studied by pupils up to the II year and in the third year this subject will be discontinued. In the third year they will study only their main subjects of specialisation (Major). The nature and contents of this course varies in different Universities. This tendency of providing some sort of opportunities to arts students to study general science is found in other countries also. It is being realised that science should be taught as a part of general education not merely in the lower classes of the Universities but also in the upper classes. It is felt that if it is taught ~~only~~ in the first or second year, ~~only~~ it will be practically forgotten in the third year when the students will devote their entire attention for their special subjects. Hence some people feel that it should be studied right up to the end of the degree course.

The scope of general science should be such as to enable the students to understand and use the scientific method and to develop an active participation in, and an intelligent appreciation of the physical and biological world. But it shall not be crowded with all sorts of topics either to give it a systematic colour or to provide for various types of human interests.

Organisation of the Course Contents:

The course of studies should be framed in accordance with the above principles. Topics must be selected from each of the major branches of science with due regard to their particular contributions to the modern social life. Their basic Vocabulary, the major concepts and generalisations should be included in each of the cases. But the

tendency on the part of the academic scientists to include all sorts of topics of their branch is frequently noticed. This will make the general science course not merely difficult but even gradually unpopular. It must be remembered that the purpose of that course is not to make ^{the} non-science-specialists qualified scientists in each of the different fields of science. It should just be a course of introduction ~~to~~ the different branches of science so that they may be facilitated ~~to~~ increase their experience in those fields by their ~~own~~ own interest and further reading.

II. General Science for Science Specialists: In the case of those students who specialise in one or the other branches of science in the degree course there is provision for them to study one branch comparatively to a deeper level and totally neglect the rest. There is a growing tendency both in Europe and in America to provide a broader based education in science for the first half of the degree course and to permit specialisation in one or two branches of science in the remaining half of the course. This is clearly exhibited in the courses of studies of the newly started University of Northstafordshire in England and in the survey courses in science provided in many of the American Universities. In the Northstafordshire University the degree course is one of four years. During the first year all branches of experimental sciences are studied by all students whether they are going to specialise in science or humanities. The first year course provides a broad foundation for specialisation. During the remaining years though specialisation is permitted they have to study some subjects in addition. Those who specialise in social

sciences or humanities will have to study experimental science also. Those who specialise in experimental science will have to study some subjects under humanities or social sciences. The particular interest in ^{the} foundational course is that it includes the study of some aspects of history and philosophy of science as well as the methodology and its application to human affairs. If specialization were to be followed on that broad-based general education in science the pupils will be able to appreciate the human endeavour underlying the development of the subject. Though one will specialise in one branch of science to a deeper extent he will not be ignorant of the basic vocabulary, fundamental concepts and principles of other branches of science.

Similar tendencies of devoting the first half of the degree course (intermediate) for general education and the remaining aspect for specialisation was also existing in the Indian Universities till recently. Of course now the Universities have instituted a three year degree course retaining the last three year course for the University and adding the first year course to the secondary schools. In some of the Universities science is studied as a subject of general education during the first two years in the degree class. The Report of the University Education Commission of 1949 has expressed that such a type of distribution of General Education courses is not profitable. The Commission feels that such a thing will make the students feel that general education is after all unimportant and that they advocate that such a scheme should continue till the very end of the course. No doubt, this is a sound suggestion but the work of specialisation in any particular branch may be handicapped. So far as the provision for general education in science to science specialist is

concerned the following scheme is suggested with the end in view that neither the general nor the special aspect of science education should suffer:

In the case of those undergraduates who specialise in one or the other branch or branches of science, provision may be made for the study of the following aspects of science during the period of the course. It may be made an examination subject like other subjects. It may be included in the scheme of examination so that the students may realise its importance. The course may include such topics as:

1. History and development of science,
2. Science and Religion,
3. Scientific outlook and scientific attitude,
4. Scientific method - its development,
5. The inducto-deductive technique,
6. The impact of science on society,
7. Science and human civilisation,
8. The limitations of science,
9. The future of Science,
10. Science - its charms and horrors,
11. The particular contribution to human good by
the different branches of science, etc.

In view of the limitless range of applications of science to human fields it becomes evident that only a selected list of topics, as listed above, is to be prepared to serve the purpose of general education in science. Hence the work of selecting the contents for general science becomes very important. We should remember that the

problem of selection finally will reduce itself to the problem of what ^{to teach} rather than how much to teach. Every topic we include under this scheme, should contribute to illustrate or elaborate those aspects of science that are dominant by their application to life.

Students specialising in science may be asked to acquaint themselves with the great classics of science like *Origin of species*, *Principia*, *Optics*, etc., to give them an idea as to how the minds of great scientists worked.

The inclusion of the above general science course is intended to provide an all-round science education to those who specialise in science. The work of specialising is no doubt, ⁱⁿ more important aspect of the degree course but the general education, provided by science, becomes equally important when we realise that the scope and purpose of specialisation becomes more meaningful in the light of the history, meaning, method and effect of science as a whole. One may feel that many topics of interest are to be included in the general science course. Of course, there are so many topics. But proper care is to be bestowed in selecting those contents that are of particular use. A rigorous and discriminating examination of the contents should ensure that only the more important ones are included while those that are less important ^{ones} are excluded. Those topics that are included must be such as to influence a more exacting influence on higher education and to demand on the part of students, a living interest, creative thinking and freedom to explore.

A list of topics included in the science course of the Foundation ^{at} year in the North Staffordshire University is given below

to illustrate the range and scope of the science course for general Education:¹

1. PHYSICAL ENVIRONMENT

1. Newton's Mechanics,
2. The Sky,
3. The Solar System,
4. The Stars,
5. The Universe,
6. The Earth's Crust,
7. The interior of the Earth,
8. The waste of the land,
9. Sediments,
10. The Dating of the rocks,
11. The procession of life,
12. Geological time and age of the earth,
13. The changing earth.

II. THE PHYSICAL BACKGROUND:

14. Work, Energy and Power,
15. Gases,
16. Chemists View on Matter.
17. Electricity,
18. Electrons,
19. The structure of Atoms,
20. Atomic Nucleus,
21. The Periodic table,
22. Building Molecules,
23. The Uniqueness of Carbon,

III THE EMERGENCE OF MAN:

- 24. What is a living thing?
- 25. Conditions necessary for life,
- 26. The Mechanism of Evolution - Reproduction,
- 27. The Mechanism of Evolution - The Physical Basis of Inheritance,
- 28. The Mechanism of Evolution - The Element of Change,
- 29. Evolution of Man.

IV MAN AS A LIVING ORGANISM:

- 30. Man as a mechanism,
- 31. Physical Basis of Sensation,
- 32. The Nature of Human Experience,
- 33. Human Organisation and Behaviour,
- 34. Enzymes,
- 35. Food and its uses,
- 36. Nutrition,
- 37. The Reproductions cycle.

V MAN AND NATURE:

- 38. The causes of diseases,
- 39. The Biology of disease control,
- 40. Vaccination and Immunisation,
- 41. Chemistry and the treatment of disease,
- 42. Mental disease and Mental Hygiene,

CONTRIBUTIONS OF SCIENCE TO SOCIETY:

- 43. The Geology of Mineral Deposits,
- 44. The rise of modern iron and Steel Industry,

45. The rise of the Chemical Industry,
46. The Modern Chemical Industry,
47. Plastics, Synthetic Rubber and ~~Kantexia~~
Man-made-fibres,
48. Science and Agriculture,
49. Electrical Power,
50. The Geography of Power Supply,
51. Availability and efficiency of sources
of power,
52. New Sources of Power,
53. Nuclear Power,
54. Telecommunications,

VI MAN AS AN ORIGINATOR:

55. Man as an originator,
56. The invention of inventions.

The list of topics indicated above is intended to serve the purpose of general education in science, not merely for those who are going to specialise in experimental science, but also for those who are going to specialise in other groups, namely, humanities or social sciences. It is a common course for both science and non science specialists. The list no doubt, includes to a great extent, the systematic topics of the different branches of experimental science; but the topics are arranged in a peculiar order based on human interest. This course is intended only for the first year of the University and to be dropped off at the end of that year. One may feel that the influence of the course, however good it may be, ceases to operate effectively in the later years of the University course. If the above

course were to be spread over the greater part of the University education and if specialisation were to start from the first year itself, the adverse effects anticipated by the above criticisms may be avoided. However, the list includes some aspects of science for general education for those who are going to specialise in one or the other branch of knowledge.

The sub-committee appointed by the Committee of Vice-Chancellors of the English Universities to consider the University entrance requirements, stated in their report in 1956, that "Universities and schools have a common interest in the promotion of a well-balanced and liberal education side by side with appropriate specialised studies." The committee further viewed that a student may fail to take the full advantages of the manifold opportunities provided by the University education unless a foundation for broader interests is laid in the schools and that the fruitful avenue for such a broad foundation should start at the sixth form and go right upto the end of the degree course.

Broadly speaking the University Education of science specialists should go on side by side with a broad general education ⁱⁿ that subject. It is better to spread this general education course of science over the whole of the degree course. At present such a course is either restricted to the intermediate or pre-University stages where students study more science subjects than they are going to specialise in the degree course. But the existing general education course which may spread over the greater part of the university course is quite peculiar. For Science specialisits there is a course of social science and for those who specialise in humanities there is a course of general science.

The purpose of such a course is quite different. It is to make scientists more humanistic and artists more scientific. But what we mean by general science education for science specialists is quite different. Its purpose and scope also are different as stated above. The main purpose of that course is to provide an opportunity to the science specialists to have a broader concept of the field of science, as the foundation on which they have to build the tower of their specialisation. Such a course naturally consists of the following five fields of study.

1. Historical development of Science,
2. The Method of science,
3. Science and our changing values,
4. The contribution of science to human good,
5. The need for using science only for the good of mankind and not to his destruction.

Suitable topics covering each of the above fields may be included and the study of the same should be spread over the whole course. If possible an examination in this subject may also be held at the end of the course. If that is not possible a few questions on general science may be included in each of the special papers. In the words of the University Education Commission 'such a course in general education will go to correct the extreme specialisation which is common in our degree programme'. In addition, it helps the science specialists to get a fuller and more meaningful view of the narrow subject in which they are specialising.

Standards of Achievement in Science:

It is common to state that the standard of pupils' achievement

is dependent on the standard of teaching though the former is controlled by other factors such as the pupils' learning capacity, suitability of courses selected, pupils' attitude towards study and the different educational facilities at the disposal of the pupils and the way in which those facilities are made use of.³ This fact becomes more evident with regard to the achievement of pupils at the University level where they are expected to carry on independent study to a great extent. What ever it may be, it is generally believed that the pupils coming from intermediate colleges to the degree classes are poorly grounded in science. This is evidenced by the fact that a good many pupils are not promoted from the first year to the second year degree class. As quoted in the Report of the University Education Commission of 1949, during 1944-45 only 72 % of the pupils passed from the first year B.Sc. to the second year B.Sc., whereas during the same period the average percentage of passes from the second year B.Sc., to the third year B.Sc. was only 62 %. It becomes clear that there is a heavy wastage in the science courses. This wastage is estimated to amount to about 50 %. As indicated in an earlier chapter there is nearly an equal amount of wastage when pupils take up final year examination. In England, admission is made to the degree courses very carefully, insisting upon higher standards of performance in the G.C.E. examination. This naturally reduces the wastage considerably. Even among those who pass in the final examination the percentage of those who pass in the III division, is too high ranging from 20 % to 75 %. This wastage should be considered as a national problem and every effort should be undertaken to reduce the same. More careful admission, smaller number of students, greater amount of individual

attention to the pupils in their laboratory work may go to improve the standard of pupils' achievement in science, thus preventing the enormous wastage in science education at the university level.

III. Science Education at the Research Level: Human civilisation of the present day is the result of the accumulated wealth of contributions by individuals at different times in the history of mankind. Those particular contributions were from those individuals who could go deeper into the fields of nature and the purpose and processes underlying human behaviour. The complex civilisation of today is certainly the result of narrow specialisation and research. In this connection we may quote a statement from Whitehead, the English Philosopher:

" a progressive society depends on its inclusion of three groups: Scholars, discoverers, inventors".⁴

As expressed in the University Education Commission's Report of 1949, such "scholars rediscover the past and set before us ideals of wisdom, beauty and goodness; discoverers find out new truths and inventors apply them to present needs". The universities are the chief agencies for producing the above three types of men who could bring together the progressive activities into an effective instrument of social utility and progress. This sacred work of advancement of knowledge is as much a responsibility of the universities as it is with their work of training citizens. In fact mere teaching gradually degenerates if it does not find its root in research. Hence all the Universities in India to-day, cherish as their objectives, the advancement of knowledge through ^{research,} in addition to their teaching programme.

In our daily life we use the automobiles, the aeroplanes,

the radio, refrigerator, cinema, cement roads, penicillin and other wonder drugs, disinfectants etc., which are the fruits of research studies or discoveries or inventions. Every state whether advanced or backward, is trying to make use of science and scientific research to improve the position of food, communication, defence, supply of energy, health and sanitation. Science as applied to the above fields, always follows the pure disinterested research work in the laboratories, most of which are located in the various science departments of the Universities, though a few of them are started and maintained directly by the states and the Central Governments. The Universities have to discharge the double responsibility of contributing directly by their fundamental research, to the advancement of knowledge and progress of life and to the producing of enough research workers to undertake research work either in the National or State Laboratories. Therefore training in research work is ^{as} important to the state as advancement of knowledge is important to the intellectual life of the nation. Hence it becomes clear that the authorities who accord sanction for the starting of the Universities and provide funds for their maintenance, will have to ensure that those universities assume not merely the responsibility of teaching but also the responsibility of organising research work and the training of research workers in the field of science.

Growth of Research Movement in Indian Universities:

For a long time the three major Universities of India namely the University of Calcutta, Madras and Bombay remained affiliating Universities. Only a few individual scholars conducted research

on their own line and no organised attempts were made to train research workers and to start centres of research, in any University. It was only in 1914 that post-graduate departments were formed at the Calcutta University. After the first world war new Universities, were started. Some of them that were teaching universities started post-graduate training and research from the very beginning of their origin. Later the affiliating Universities also started post-graduate research courses. The organisation of research in several University departments raised the position and status of research and post-graduate teaching. The scientific research activity which was till then, mainly the concern and monopoly of the Government Scientific Services, passed over largely to the University departments after 1920. Practically in those days ~~there~~ no grants were given by the Central Government for fundamental research except those that were given for agricultural and medical research. Yet, some of the Universities did some creditable research work in the field of fundamental science.

Dr.S.S.Bhatnagar giving his impression of the particular difficulties encountered by the research workers, in the form of a report before the Royal Society in 1946, has expressed the following views:

"Lack of equipment, lack of accommodation, long hours of routine teaching work, due to insufficient teaching staff and finally, the eternal want of funds are some of the problems that handicap science teaching and scientific research in Indian Universities".⁵

In spite of the above difficulties substantial post-graduate teaching work and research in the field of science have taken place during the last twenty five years. Yet the amount of research work done by teachers or research students does not approach to what it should be.

There may be a few distinguished research studies undertaken here and there. But in a vast country like India the quantity of work done should be substantially of a higher magnitude. Even the general average quality of work done required improvement in all the Universities. Most of the research studies are the theses for the D.Sc. or the Ph.D. degrees. During 1938-1948 the number of such research studies in all the universities of India in the six basic sciences amounted to 260, an average of 26 studies per year. It may be noted here that ^{in Cambridge alone} during 1935, there were more than 400 people engaged in scientific research.⁶ This clearly indicates how little research work is being undertaken in our Universities. In the subsequent decade this number was smaller still, probably because, the Universities could not get proper persons for their science departments to guide post-graduate research studies.

The value of the research studies can be better assessed by their publication. Further the particular influence of those studies on the growth of knowledge is possible only when they come to the notice of the scholars. Hence it becomes clear that it is the responsibility of the Universities to see that the theses accepted for doctorate find the light of publication at the earliest time after the award of the degrees. This is equally necessary in the case of research studies in the field of the different basic sciences conducted by the research fellows and the members of the teaching staff.

The report of the University Education Commission of 1949 [✓] states that the University teachers are privileged persons having plenty of ^e leisure and enjoying a life of tranquillity and as such they

should give in return, to the community, the gores of new ideas and newer methods in relation to their research work. The report definitely states that the members of the University teaching staff should be not merely for imparting existing knowledge but also for creating newer knowledge.

Static

The static^{Static} of mind on the part of the teaching staff and the heavy load of teaching work are two important factors that are coming in the way of conducting research studies in the Universities. Lack of financial assistance is also another factor. In recent years the University Grants Commission is making liberal grants to all the Universities and the affiliated colleges for this purpose. The commission is thereby contributing for the growth of research work in the Universities. Almost all the Universities have appointed research staff under the University Grants Commission Scheme and they are definitely charged with the function of doing ^{and guiding} research work. They are freed from much of the teaching load which might come in the way of research work. It may be mentioned here that there is need for selecting for this purpose only those who can do substantial work in the field of basic research. Further, proper co-ordination between the work undertaken by the departments of the different Universities is also essential. The University Grants Commission is to some extent doing this work while approving the programmes of research work for each of the departments of the several Universities.

Methods of Instruction:

The common method of science instruction at the University level is the lecture supported by demonstration or experiments. The

effectiveness of this technique depends largely on the carefulness with which the teachers prepare for their lectures and demonstrations. Many a time it is found that the lectures are dictated including the details of the experiments. This aspect prevents the pupils from preparing their own notes on the one hand, and from understanding the lecture thoroughly on the other. In addition, many students feel that the dictated lecture is quite adequate and do not pay sufficient attention for further study and independent laboratory work. Some times, when the dictation technique is not resorted to the lecture may take the form of fluent public oratory! Naturally, the students may not be able to follow the chain of arguments, at least, in the early years of the University education. Hence it becomes clear that the technique should not vary much differ from that which is in use in the secondary schools. The lecture should be punctuated by interrogating the students and even by lecturer being interrogated by the pupils on significant points of the topic. The lecturer may even give on the board, the main points of the topic to facilitate pupils to take down notes and to indicate the centres of focus in the topic. Gradually of course, the students must be enabled to take down notes independent of the above assistance, particularly during the later years of the University course.

Need for Better Tutorial Assistance to Science Students:

Private or personal advice by the members of teaching staff individually to the students certainly, goes a long way to improve the intellectual and moral life of the students. In the western Universities this aspect of instruction is a special feature. In the

University of Cambridge it is called supervision and students go usually in pairs. In other Universities this system exists with the difference that the number of pupils coming at a time for tutorial advice, is a little higher. A few Universities in India also have tried this technique but with larger groups. But the effectiveness of the ~~group~~^{technique} can never be fully realised in the group in India as many as twenty or twenty-five, as it becomes impossible for the teacher to pay individual attention. If smaller groups are employed it necessitates a huge expenditure of funds in maintaining greater number of members on the science teaching staff. This is no doubt, a serious difficulty but some how it is to be tackled in one or the other way to ensure proper tutorial assistance to the undergraduate science students in the Universities.

The principal function of the tutorial class is described by the University Education Commission as a kind of 'Intellectual Mid-wifery'.⁷ It includes the following types of assistance to the students

1. Direction and guidance of the thought process of the students;
2. Assistance to students to learn the method and habits of analysis, judgement and evaluation while the subject is being discussed with the tutor as the leader;
3. Advice regarding the selection of field to study, lectures to attend and the particular points on which attention is to be concentrated, and
4. To assist the students to solve some of their felt problems, intellectual or moral.

The tutorial method can be used as a teaching device to

supplement the class lectures. Answers to questions, essays on topics of science and the application of some of the principles to problems of life may form subjects for the science tutorial classes. It is possible that the students in a small tutorial group will sharpen ~~in~~ their wits while discussing some of the topics of science in their theoretical and practical aspects. They will profitably benefit by the mistakes of their own and by those of others.

Realising the educative values of the tutorial system the Ministry of Education on the advice of the University Education Commission and the University Grants Commission, is trying to encourage tutorial system for the undergraduates in our Universities. They are also prepared to share to some extent the additional expenditure that the Universities will have to incur ~~in~~ this behalf. The introduction of tutorial assistance to University students will contribute for the effectiveness of the University Education.

Seminars and Workshop Practices for Post-Graduate Students:

The tutorial is a device by which a master guides a novice whereas a seminar is a group activity in which mature people engage themselves in joint discussion on one or the other topic of a subject. One of the members of the group has to open the topic with his thesis and others will express their opinion on the various aspects of the subject freely, with the idea of stimulating discussion, clarifying issues and arriving at the truth through their co-operative effort. In one way, the matured experience and intellect of the group are contributed to arrive at the truth. In this respect it forms the laboratory or a common sense experimental approach to the solution of a problem. Hence

it forms part of the post-graduate research technique. This technique of study is an American contribution. It is becoming popular both in U.K. and in the continental countries. Even in India, it forms the popular study technique for experts when they meet in groups.

In addition to the seminar technique, another study technique that is coming into practice, is the workshop method. This is found to be a useful technique to provide experience in the practical aspects of the subject. Seminars and workshops as postgraduate techniques of study may be introduced at the post-graduate level for those who take up science problems for their research work.

Laboratory Discipline for Science Students:

One of the important aspects of University education is the development of a discipline particular to the course of study selected by the students. This discipline is best developed through a course of practical work designed for the subject. This necessitates the availability of suitable building facilities with proper fittings and essential equipment. Science teaching and research in the basic sciences are recent introduction in our Colleges and Universities as such most of the laboratories were built during this century. No doubt, laboratories were built in the later part of the last centuries also, both in schools and in colleges; but they were of a very crude nature and were thoroughly unsuited for modern laboratory work. Attempts have been made either to modernise them or alter them by the addition of more rooms, providing ventilation and installing suitable fittings. Some of the modern laboratories built by reputed firms are however, well planned. It may be necessary on the part of the University Grants

Commission to maintain standard designs for laboratories in chemistry, botany, zoology, physics, geology etc., and to insist upon the Universities to follow the designs when ever they undertake construction or extension of laboratories under the U.G.C. Scheme.

Science teachers in the University and Colleges generally complain that they have no adequate equipment. In recent years there is a ~~stead~~ increase in the number of students coming for science courses and as such serious difficulty is being encountered in ^maccommodating. Modern science teaching and research work require not merely good building facility but also adequate and even costly equipment. To facilitate research in the several basic sciences it is essential to provide adequate apparatus to follow newer techniques of study. These apparatus~~are~~ are generally very costly but the Universities and the College ⁻⁵ where provision is made for such studies, will have to supply them. Naturally they are required to have adequate capital and maintenance grants for the purpose. Most of these newer apparatus and appliances are to be purchased from outside and there comes the exchange difficulty. The Central Government therefore, will have to make adequate laboratory grants to the Universities through the ~~the~~ Grants Commission and issue permits for purchasing those apparatus and appliances from foreign countries. In addition, there is an urgent need for starting a Central Laboratory workshop to undertake the manufacture and supply of the apparatus and appliances required for the laboratories of the Universities for the various departments of basic sciences. It is also necessary for each College to maintain a workshop for effecting certain repairs to apparatus and appliances.

It is gratifying to note that in recent years, the University Grants Commission has come forward to assist through liberal financial aid, to improve the laboratory facilities for making the practical instruction more effective to the Science students and to provide adequate laboratory facilities for the post-graduate research studies. It is expected that this aspect of the Central assistance combined with the U.G.C. scheme of appointing research staff, will substantially improve the position and status of post-graduate studies and research in our Universities and Colleges.

Trained Research Personnel for the National Laboratories:

In recent years the Government of India has started a number of national laboratories where scientists of high quality are facilitated to conduct research work as applied to the different fields of human activities. Usually the research that is undertaken in the Universities and Colleges are of a basic type intended to advance the cause of knowledge about the nature of man and the Universe. In the national laboratories and the higher technological institutes for post-graduate studies, applied or developmental research is undertaken with the idea of applying the discoveries of pure science to definite objectives of life. It is by their effort that engineering and technology have advanced. But the success of those institutions where applied science research activities are undertaken, depends largely on the type of scientists and science research workers that are trained in the Universities and Colleges. Naturally, they will constantly watch for the Universities for a continuous supply of man-power highly

trained in fundamental or basic science research. If the country were to strengthen its national economy through progressive industrialisation those national laboratories will have to function effectively in carrying on research work of applied and developmental type. This further necessitates the ~~work~~of strengthening the science laboratories in our Universities and Colleges. In a recent report, ~~of~~ a Committee of Educationists in England, while investigating the position of Grammar school laboratories, expressed the view that the defensive strength of the country and the strength of the national economy in the modern age, lie not in the factories or foot-ball fields but in the school laboratories. This realisation indicates the particular care we have to devote for ^{the} development of our laboratories in schools and colleges. Dr. Bhatnagar, the veteran scientist~~s~~ of our country, once expressed the view that we have to depend upon Universities for fundamental researches which are the source from which extraordinary applications are likely to emerge. Thus the science laboratories of the Universities and the Colleges will have to be treated as the fountain heads of pure research, essential for the development of applied or developmental research in the different national laboratories. Therefore the improvement of those laboratories for the organisation of an effective research programme becomes all the more an essential part of the Universities and science colleges on the one hand, and the state and the central governments on the other.

Financial Implications:

The Scientific Man-Power committee in 1948, in their developmental plans for the improvement of higher scientific education and

research, proposed that the Central Government should provide an additional capital grant of Rs 494.735 lakhs and a maintenance grant of Rs 60.0806 lakhs per annum over and above what has already been provided by the Central and the State Governments. The capital grant was intended for construction, extension and improvement of buildings, equipment and fittings where as the maintenance grant was for the purchase of additional apparatus and appliances as well as for equipping with chemicals and other materials.⁸ Similar increase from the pre-war maintenance grant of £ 3.66 lakhs to £ 10 lakhs was recommended to their Government by the Council of the Royal Society of Science in London in 1946.⁹ The British Government was pleased to consider the suggestion and trebled its prewar recurring grant. This earnestness was due to its realisation of the fact that fundamental research was essential for the country's all-round progress and that such a scheme requires the improvement and extension of University laboratory facilities. The Government of India realising the importance of the above programme, has increased its capital and maintenance grants to the several Universities through the University Grants Commission under the encouragement to University Grants Commission Research scheme. This is clearly exhibited by the fact that the outlay of funds for the University education in the second five year plan was raised to Rs 57 crores whereas it was only Rs 15 crores in the first five year plan.¹⁰ These liberal grants from the Central Government will certainly go a long way in improving the existing laboratory facilities in different Universities, for Post-graduate research and ^{for the} training of research workers.

Laboratories for the Newer Fields of Research:

Though the subject of science is divided into a number of branches for purpose of academic convenience and systematic study it is to be remembered that there exist no exact dividing lines between the different branches of science. Many a time the areas of two branches will overlap. This division is unnatural since the knowledge of the different branches of science will normally participate together in the happenings or the operations of nature or in the affairs of man. Hence it is not unusual that a chemist may require certain knowledge for his studies from physics. This area of common knowledge where two branches overlap is what is known as the border-line science.

The rapid growth of the knowledge of science has opened up newer fields of study. Among them, the border-line sciences like Biochemistry, Geochemistry, Geophysics, Mineralogical Chemistry, Paleozoology, Paleobotany, Geophysics and Astrorphysics have opened up newer fields of study and research, particularly because of their very useful economic and industrial implications. These border-line sciences are ultimately relevant to the six basic sciences, like Physics, Chemistry, Botany, Zoology, Geology and Astronomy. Hence the study of any border-line science requires the fundamental knowledge of any two of the basic sciences. Therefore these border-line sciences as subjects, either for study or for research, will have to be introduced only at the post-graduate ^{level} ~~as well as our basic science programmes at the degree level~~ in the Universities. Hence our laboratory organisation and equipment as well as our basic science programmes at the

degree level, should be perfected before we could think of introducing the study of border-line sciences at the post-graduate level. As a result of our deficiency with regard to the teaching and equipment standards in basic sciences the introduction of those newer sciences has been delayed. Because of the medical needs however, Biochemistry has made some strides to become a popular subject of study in some of our Universities. Except in a few Universities Biochemistry is considered as a sub-department in the Medical College, offering facilities for the Post-graduate students to study for their Master's degree in Bio-chemistry. But the University Education Commission of 1948 realising the potentiality of the applications of this science to human affairs, has expressed the view that we must recognise its status as a separate subject and should have separate post-graduate departments of Bio-chemistry in the Universities. Following this suggestion attempts are being made to have separate Post-graduate departments of Bio-chemistry in most of the Universities. Other border-line sciences have yet to find ^{their place} in our Universities, their separate and independent status among the post graduate departments of study. Since they are all newer developments in the field of science and have not been studied by the students in the degree course the post-graduate departments of border-line sciences should not restrict themselves to mere research, but must undertake post graduate teaching work also.

While attempts are being made to start border-line science departments at the post-graduate level, it is necessary that the Universities will have to improve their standard of instruction in basic sciences and their laboratory equipment on the one hand, and ^{the} state and Central Governments will have to give adequate capital and maintenance grants to basic sciences ^{departments} ~~in the~~ on the other.

Need for Encouraging Marine Biological Studies:

Biological Science entered into our school curriculum much later than the physical sciences could enter. Even to-day, in many states, schools teach only physics and chemistry as science, neglecting biological science. Even where it forms part of the curriculum it does not enjoy the same status as the other two sister branches of science. A few topics of animal and plant studies with some topics of human physiology, form the biological portion of the general science course. Even in the scheme of examination it does not have the same amount of importance as the other two branches of science. This neglected state of affairs is mainly due to the step-motherly treatment given to this subject at the University level. Our Universities and Colleges included Biology as a subject of study at a much later date than physics and chemistry were included. Until very recently, biology was being taught only upto the intermediate or the undergraduate level in a number of universities and colleges. Only in a few Universities provision for post-graduate studies and research was made. It should be realised that biological science has made important contributions to our understanding of ourselves and our environment. No one can overlook the fact that it has revolutionised our affairs with regard to food, clothing, health, sanitation, agriculture, horticulture, industries, etc. Naturally it claims a better place in our schools and colleges as a subject of liberal education. Hence it is necessary to make better provision for its study at the ^{degree and ~~sta~~ and} post-graduate ^{research} levels.

Following the recommendations made by the Secondary Education Commission of 1953, all states in India are trying to reorganise the

curriculum of their secondary schools. In the ^{new} set-up all the states are endeavouring to introduce a course of general science in which biology enjoys the same status as the other branches of science. Physics and Chemistry can no more dominate in the general science curriculum since it includes topics of all branches of science. After the introduction of the three year degree course in the Universities the position of biological sciences seems to have improved to some extent.

Another important fact about the study of biological science at the University level, is that very little provision has been made for the study of a very important section of that subject, namely, Marine Biology. Of the thirty eight Universities only four or five are situated on ^{or} very near the sea coast. The rest of the Universities are situated away from the sea and as such, it is difficult for them to include practical aspect of the marine biology. Bombay, Travancore, Madras and Calcutta Universities are situated on the sea coast and do have some facilities for teaching marine biology. Waltair which is very near the sea coast also enjoys the same facilities. But there is no proper provision even in those Universities, for teaching this aspect of the subject. There is a marine aquarium at Trivandrum and another at Bombay. ^{New ones are started at Mangalore and Kochin} There was another Aquarium in Madras which was taken over during the war time for military purposes, but it has to resume work. But even there marine centres do not possess necessary equipment, collection boats, trawlers, nets, preservation and supply schemes. In recent days, another marine station has been started at Chidambaram

India has vast seas with full of animal and plant life. It is necessary to harness this natural resource for the social and economic

progress of the country. This is possible when we fully explore the potentiality of the above resource. Unfortunately most of our Universities are situated far away from the coast. This has necessitated our Universities and colleges to restrict their biological science courses to the study of animals and plants on the land and in the fresh water. A few of the Universities however have made an excursion to sea coast for a week or ten days, compulsory for the honours and master's degree courses in zoology and botany. But this provision is not at all adequate for a thorough exploration of the life in our seas. Yet the study of a good number of marine specimens is included in the courses of studies. The students will have to satisfy themselves with the study of the preserved or dead specimens. This naturally cannot enable them to understand either the nature and scope of the marine life or the potential biological resources of our sea. As a result, we cannot harness that aspect of our natural resource and to that extent, it will be an economic loss to the nation. This state of affairs is directly the result of our restricted study of biological science in the Universities and colleges most of which are situated on the mainland.

An effort on the part of our Universities and Colleges to make provision for the effective study of marine biology as part of the academic course, will not merely enrich their scientific teaching and research programmes but also lead on to the commercial exploitation of the sea. This is all the more important when we are trying to achieve self-sufficiency in food since fish which forms the food of the majority of people of this country is available in plenty in the sea. Further, there are different types of large size mammals which are of economic

importance. ~~Ciant~~(Algae of the sea which is the source of iodine and other chemicals of a costly nature, are also to be studied and used for our ever-growing industries. Hence it becomes a national problem to see that that provision and facilities exist in our Universities and colleges for the study of marine biology, both at the undergraduate and at the post-graduate levels of instruction.

A Scheme for Improving the Facilities for the study and Research in the Field of Marine Biology.

Efforts are being made from 1920, to improve the existing facilities for the study of marine biology by starting biological stations. It is only in 1945 that the Government of India added a 'Fisheries Department' to the Ministry of Agriculture. This Department was first located in Madras and now it has been shifted to Pantapan station in the East coast. It is hoped that this and other stations will serve as the institutions to provide facilities for Honours and B.Sc. students to study and get trained in the marine Biological techniques.

The Central Fisheries at Mandapam and those at Trivandrum, Chidambaram, Bombay and ~~Madras~~ should form the four centres to train the undergraduate and post-graduate students of ~~the~~ biology of our Universities. New ones can be organised at Waltair and Calcutta. It is expected that such a training will have to be given to pass course students as well, as Honours Courses are being abolished in all the Universities of India. But the pass course students amount to several thousands and as such it will be very difficult to provide all of them, facility in those stations. At least, they can be taken to the sea or the biological

stations to acquaint them ^{selves} with the actual living conditions of the marine life.

But the post-graduate students of our universities and colleges will have to go to the marine stations and study the marine life systematically. Of course, the Universities will have to make this study compulsory and resolve to take the work done in this connection, as credit for the examination. Thus a sort of seriousness into the study is essential to be installed.

The stations may maintain trained personnel on their staff to teach the students of the inland Universities. The staff of the Biology departments of the four marine Universities may also have to participate in providing ~~those~~ training facilities for the inland University students. It is also essential for each of the inland Universities to send some younger members of the staff of the ^{departments of} zoology and botany ~~departments~~ to get training in the marine biological techniques, in any of these stations.

The course of this training must extend over at least, four to six weeks and should be made compulsory for all those students who take up zoology or botany as their major subjects. Short excursions to those stations may however, be arranged for those students who take botany or zoology as minor subjects. Training in the marine biological technique in its regular sense, is to be given to all post-graduate students of botany or zoology in addition to their studying the subject systematically. A regular scheme is to be prepared by the Central Marine Fisheries in ⁻⁴⁻ consultation with the other marine stations and those inland universities where there are post-graduate students in zoology and Botany. The

Study and training of those students must be spread over the whole year according to a prepared plan of distribution of students to the above four centres. Boarding and lodging facilities at each station, for at least twenty pupils may have to be arranged. The Indian Universities will have to send their students according to the scheme of distribution programme prepared by the central Fisheries at Madras. Each University may send one or two members of the staff to guide the students during their stay. But much of the teaching and guiding work is to be done by the special staff maintained by the centres. The staff of the local University departments may also co-operate in this training programme.

This scheme involves additional cost to the Universities and the Colleges. But it should be realised that the cost to be incurred in this behalf, is practically nothing when compared with the immense possibilities before the country. Hence, the additional expenditure essential in this connection, can be got sanctioned by the Government. The University Grants Commission may also sponsor a scheme to improve the study and research in marine biology. The additional cost to be incurred in this connection, may be shared by the concerned Universities and the University Grants Commission.

Developing our Marine supply Centres:

It is estimated that the greater part of animal life and a substantial proportion of plant life are inhabiting in the sea. The study of Botany and Zoology or Biology includes the study a good many species of plants and animals that live in the sea. This necessitates all the schools, Universities and Colleges that are situated away from

the coast, to get a good lot of marine specimens imported. A number of commercial stations are started in many countries to undertake this supply to the different parts of the world. France has the largest number of marine stations. Britain has a number of marine stations at Plymouth, Port Erin, New Castle and at other coastal towns. There are good marine stations at Murmansk, Varna, Sebastopol, and other coastal towns^{in Russia.} The marine station at Woods Hole in U.S.A. is the biggest in the world. The above centres in addition to the work of supplying specimens to the laboratories of schools and colleges, serve as training centres for marine biological studies and research work. They are generally controlled either by the Universities or by the Governments. At present most of the marine specimens that are imported to the laboratories of Indian Universities, Colleges and schools are to be purchased from foreign marine stations, as such, a good lot of money is leaving India. Hence /in these days of exchange difficulties, it becomes all the more clear, that we have to develop our existing marine stations and start newer ones to serve the double purpose of training our students in marine biology and the work of supplying the marine specimens to the laboratories of the schools and colleges that are situated in the interior of the country. The development of these stations not merely completes the present deficiency in the study of biological sciences in our Universities but ultimately, also contributes for the strengthening of our national economy to the extent it will enable us to harness the resources of the sea.

Science in the Professional and Technical Education:

The application of the principles of science to the art of industry has led to the development of Technology which along with

engineering, forms the frame work within which the national economy of any country will have to operate. So, it is reasonable to expect that the strength of the national economy of a country depends upon the organisation of industries on technical lines. Hence, all states will have to ensure that suitable man-power is produced by the organisation of a system of professional and Technical education.

Professional^{al} education is conceived as a process of preparing men and women for exacting, responsible service in the professional spirit. Professional education may^{be} applied preferably to those professions that require well informed and disciplined weight and skill of a high standard. The less exacting preparation may be termed as vocational or technical education. Preparation for exacting service through a well-disciplined scholarship and training, able to live and work in the spirit of professional standards, shall entitle an individual to be considered as a member of a profession. There was a time when the western countries had recognised only three professions. i.e., theology, law and medicine. Later on architecture and engineering also came to be recognised as professions. To-day a good many of the other callings also demand equally disciplined and orderly training. Dentistry, journalism, teaching, librarianship, forestry and nursing are generally considered as professions. But^{it} must be remembered that every calling in life is trying to demand more exacting service with discipline, insight and skill and as such all callings are trying to emerge out as modern professions. Hence it becomes difficult to associate the term profession to any one calling. Rather it is gradually coming to mean professional standards and attitudes.

The Principles underlying the Professional Education:

Education for any modern profession includes not merely the technical skill and discipline connected with the particular calling but also that aspect of general education which can infuse into the personality of the technician a sense of social responsibility, an appreciation of the social and human values and relationships and a disciplined power to see realities without prejudice or blind faith. In one word, the education they receive should enable them to set the pattern of national life. Hence the education of the professional men should be so organised as to give a perspective of the whole problem of his profession both in its technical and in its human side. Technical skill, method and understanding can never work in the modern time, as isolated discipline but in a perfectly human and social setting.

The progress of modern civilisation largely consists of ^{building} newer and newer professional standards in conformity with the human and social relations. For the well being of mankind the progress of civilisation should also ensure the progressive establishment of social peace and harmony. This can be realised only when professional students are taught the humanistic, social and basic science subjects in addition to the methods of professional education. Hence it becomes clear that it is the responsibility of all those who are concerned with professional education that adequate general education is imparted to those students either before or along with the professional education, preferably the latter. It is our concern here to study those aspects of professional education as related to the basic or applied sciences.

What ever may be the profession for which the pupils are trained it is essential to ensure that the course provides a broad general education. This includes all those subjects that possess the experiences relevant to the operation of that particular industry in a human and social setting. Among those subjects it is needless to state that the several basic sciences play a dominant role. Those basic sciences may include courses in physics, chemistry, botany, zoology and geology. Nearly one fourth of the total period of training is to be set apart for this aspect of the course. The selection and organisation of the topics of the basic sciences as well as the approach to the teaching of those topics should exhibit a liberating academic atmosphere and research as well as a clear realisation of the relation they bear to the particular applied science on the one hand and the working and growth of the profession on the other. The amount of knowledge as well as ^{the} standard of achievement in the different sciences should be determined by the requirements of the same for the understanding of the particular level of professional course.

The Three grades of Professional Courses and the Nature of Science Courses both General and Applied, at each of those levels:

As indicated in the earlier pages every industry requires three types of man-power - skilled labourers, technicians and the technologists or high grade engineers. The professions also are organised at three different levels. Professional education therefore, needs to be organised at three different levels in conformity with the three different grades of professional practice. Taking agriculture as an illustrative profession there is need for field workers, supervisors and specialists

and research workers. There are sporadic courses for training the first type of man-power both in general educational institutions and in separate agricultural institutions. Since the majority of agriculturists feel that they can pick up that amount of skill and discipline by mere participation in the field work, the first course has not become attractive. The other two courses are intended to produce supervisors and technologists respectively. The institutions that offer courses for the above three types expect different educational requirements on the part of the students for admission. The institutions intended to produce fieldmen admit pupils with little general educational qualification. Those institutions that are intended to train supervisors or technicians admit pupils after the school final examinations. The third type institutions admit undergraduates and post graduate students. These three categories of institutions are in existence with respect to almost all the professions. In all cases basic sciences are generally taught to provide general education on the one hand and to provide an insight into the technical aspect of the profession on the other. In addition to the above two courses they have included in the courses of studies applied science, both theoretical and practical.

Every professional man, to whatever order of profession he may be trained, should study, in addition to those courses that directly impart professional discipline and standards, certain aspect of science which is essential for successful citizenship and certain other aspect of science which is necessary to enable the professionalist to understand the part the particular profession has played in the evolution of the human civilisation. This aspect of science may be studied as part of the history and philosophy of the subject.

It is a general complaint today, that in taking far-reaching decisions on problems of social and industrial nature, the technologists are not being consulted. In fact it is the voice of the politicians that is heard every where in matters related to important decisions ^{in those} even fields that involve technical skill and operation. One reason that is generally given for this sort of affairs, is that the technicians and technologists are specialists trained only in the narrow technical aspect of the work, but without adequate experience regarding how the professions operate in a human and social atmosphere. Though this reason cannot be accepted in all cases it is not out of the place to state that our professional men do require a broader education and a better knowledge of the role the particular industry or profession has played in shaping the present civilisation. This necessitates that every professional or vocational or technical institute should provide a broad-based general education including a historical and a philosophic perspectives of the particular profession. As part of that extended course the following aspects of science can be included in the related basic and applied science courses:

1. A broad-based general science course essential for every citizen of the industrial age to enable him to ~~enable him~~ to live successfully.
2. A brief history of ^{the} development of the particular profession and the part played by science in bringing that profession to modern shape.

The first course may either be completed before the candidate

seeks admission to the professional institutions or it may be provided along with the professional courses, in the professional institutions. The second course has to be studied in close relation to the professional course, in the professional institutions themselves. The standard expected in these two courses will vary with the level or grade to which the professional institutions belong.

If our workers in the field, technicians and technologists were to have such a broad-based education as indicated above it is possible that a new social order may evolve. The technicians and the technologists who are specialists in their own sphere will also have a clear and thorough knowledge of the particular atmosphere in which the human and social aspect of the profession operates. In other words they will have a clear insight into the human and social implications of the profession. Such people will not merely demand but will certainly have a voice in shaping the professional and industrial future of the country. As a result of such an innovation into our educational and social life the politicians and statesmen alone will not dominate in deciding the fate of the nation on the one hand, and the society can not blame the technicians for blindly working to the egoistic interest of the politicians on the other. ~~Many times determined for the broader interest of mankind~~ Now we have reached a stage, in the progress of the industrial civilisation, when the technicians and the technologist should join the other leaders in the noble task of averting the threatened disaster of human civilisation and to assure that science and technology will not dance to the mere blood-thirsty and egoistic tunes of the politicians, detrimental to the broader interest of mankind.

It is in this particular aspect of science education that we have to look for the dawn of ^a new era that ensures both the safety and the progress of mankind on the one hand and the glory of science, on the other.

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CHAPTER XXI

Need for a More Effective Central Leadership
for Science Education.

Education in India, has remained purely a state concern. Before the advent of freedom the Centre no doubt, did have a Department of Education and a Commissioner for Education. But its work was purely to collect and publish reports regarding the progress of education in the different states. After the dawn of freedom it has become the responsibility of both the Centre and the State to launch a more effective educational policy to drive ^{out} illiteracy and to prepare the ignorant millions to participate successfully in the work of the democracy. This is clearly indicated by the fact that a sum of Rs. 100 crores was provided by the Centre for the development of Education, in the first five year plan. Further, this provision has been nearly doubled in the second five year plan.

Though the Centre does not wish to interfere in the field of education with the State Governments, it is increasing its interest in the education of the people. In addition to the provision of huge ^{money} amounts ^{for} states, it is maintaining executive and technical staff to assist the state governments to implement the national schemes of extension and improvement of educational service. Here we see a gradually developing relation between the Centre and the states. This relation is now one of dictation but of guidance and assistance. The states are wholeheartedly welcoming the educational leadership of the Centre. This leadership of the Centre is one of technical and expert guidance on

educational matters on the one hand and the financial assistance on the other.

Science is a developing subject. Its nature and content is changing from day to day as a result of newer developments in the field of basic research. Further, the content of the subject, the curriculum, the teaching techniques and the aids to teach are all subjected to improvement and modification. Hence it clearly means that any educational system has to pay comparatively greater attention and devote greater sum of money for ensuring an effective instructional programme. But the states with their meagre income and inadequate technical and academic staff, naturally, may not be able to provide such an efficient instructional programme in science in their jurisdiction. Hence, it becomes clear that the Centre will have to show greater and greater interest in the science educational programmes in the states. This is primarily necessary to ensure that the future men and women of this country are rightly educated to live in an age of ever-growing scientific interest and application. Secondly, it is necessary to evince that interest to ensure adequate man-power at all levels, for the growing industries of the country on which depends the nation's economic success. Hence, it is felt that the Central Ministry of Education should provide a more effective leadership and assistance to the States in this particular direction. The Centre, no doubt, is doing a good lot of work both independently and in partnership with the States, to improve and extend the educational facilities. In the field of science ~~the~~ its interest and effort should redouble on account of the facts stated above.

The Educational leadership of the Centre is eagerly awaited by all the states particularly in the following fields of Science Education:-

- i. Acquaintance with the growing wealth of science information;
- ii. Reorientation of science programmes in the school;
- iii. Improved and effective teaching techniques;
- iv. Organisation of correlated activities;
- v. Guidance to the teachers regarding the concern or approach to the Organisation of Science Programmes in the various grades of instruction;
- vi. Resources to purchase and make use of the modern and up-to-date apparatus and appliances;
- vii. Provision for teachers to get trained in the laboratory art, craft etc;
- viii. Facilities for the schools and colleges to make use of the community resources for improving and vitalising science instruction;
- ix. The preparation of standardised achievement and diagnostic tests in science for different regions.
etc., etc.

In addition to the present developmental schemes, the Central Ministry of Education can move in the following directions, thus providing both impetus and positive guidance and assistance to the states in their science educational programmes:

1. A journal may be published both in English and in Hindi to review the progress of science and copies may be sent to all the educational institutions and the State Departments of Education.

2. The States may be requested to bring out a similar number in the regional language and copies may be supplied free of cost, to all the educational institutions so that the teachers and the educators may be kept in touch with the progress of the subject.
3. The Central Ministry of Education may publish a monthly 'Journal of Science Teaching' both in English and in Hindi to facilitate the teachers to know and adopt modern approaches to the Science Teaching. If the State Governments feel it necessary, they may be permitted to bring out the same in the regional languages.
4. Colleges of Technology may be encouraged to run courses in 'Laboratory Art Craft' to the science teachers in every state. The Central Government may provide necessary financial assistance for the scheme in addition to that which can be met out of the state budget.
5. The Central Ministry of Education may organise and conduct seminars more frequently at regional level on the teaching of science. It may even provide technical assistance to the states if they were to organise similar courses in various parts of the State.
6. Activities, as in other subjects, will certainly enrich the teaching of science. The Central Government's scheme to run Science Clubs in the schools of the states is certainly, a desirable move in this direction. But the existing provision is too inadequate. This is to be extended and improved. In this connection it is needless to state that the teachers generally require additional training. The Central Government may try to organise training courses for teachers in service, in the art of running 'Science Clubs', both at the state level and at the national level.

7. The Central Government may immediately take up the work of starting 'A Science Teachers' Association' at the national level and recognise it as the national co-ordinating body in the work of teaching science. States may also be asked to start state branches to work in close contact with the Central Organisation. This move will certainly help to a great extent to tackle a good number of problems in the field and thus help to strengthen science teaching.
8. The Central Government may assist the States both with technical advice and finance to start a library of text books in science, library of science films and a library of apparatus and appliances, in the district headquarters.
9. The Centre may try to get good text books written in Hindi and English for various grades and assist the states to prepare the same in the regional language.
10. According to the new Educational set up that is already taking shape in the country, general science is being introduced at the primary school level. At present the Central Advisory Council for Secondary Education is doing something to improve science teaching as part of its work. But there is no such organisation for the primary education. The Central Ministry may consider the question of starting an 'All India Council for Primary Education' also. This may provide a good lot of technical assistance to the teachers of the primary schools to whom the subject is new, both in its contents and in its methods of approach.

It is clear that the Union Government can provide a more effective and fruitful leadership in the field of science Education. This leadership will not merely enable the states to have more effective science programmes in their schools and colleges but also ensure the supply of suitable candidates for the professional and technological courses the success of which forms the frame-work of our national economy.

CHAPTER XIII

Suggestions for Strengthening Science Education in India.

An attempt has been made in the foregoing chapters to study the trends in the different phases of science education as observed in some of the progressive countries of the world. Though those trends cannot be implemented as such in Indian schools and Colleges, a knowledge of those trends will give us a insight into many of our own problems in the field of science education and enable ~~us~~ to solve in the best possible way. The various trends have been considered in this book in all their aspects and particularly as to which of them and to what extent and in what form can be implemented in our schools and colleges.

Like any other subject of general education science instruction is being organised ^{as} a continuous programme from the primary to the adult education stage. Every progressive country has so planned science education that at every stage in the life of the individual, there will be some definite facility for science education. Keeping the above fact in view, the observed trends have been considered in relation to the following stages of science education:-

- i. Primary Education.
- ii. Secondary Education
- iii. University Education
- iv. Professional and Technical Education.
- v. Social Education.
- vi. Teacher Education.

The observed trends have been critically reviewed and considered in the light of the particular culture pattern and environment in which

our institutions have to work. Such of these things which are really progressive in nature and which can be implemented in our institutions are listed below. However there is room for adapting these suggestions to the particular environment in which the schools of the different parts of this vast country have to work. The suggestions for purpose of convenience are grouped under the above six headings.

i. Science Education at the Primary School Level:

1. The need for providing the minimum ~~of~~ equipment of functional understanding of common concepts and principles of science and the ability to appreciate the role of science in our individual and social life may be recognised as an important objective of primary education, as specifically as is recognised in the basic education scheme.
2. A functional course of science may be included in the primary schools in the place of the existing Nature Study which has been proved throughly inadequate for a modern child.
3. Since the majority of pupils in India discontinue their education at the end of the primary school, every effort may be made to evolve a really effective science programme at that level so that they may be enabled to live successfully in an age of rapidly growing scientific and industrial civilisation.
4. It is necessary to make the primary school science mostly an activity programme. This necessitates a science room for every primary school. But it is a very costly programme to undertake. But yet it is essential. A simple science room with the minimum apparatus and appliances may be provided to all the primary schools

Public co-operation may be earnestly sought in this direction.

A nation wide scheme to add 'A science room to our primary schools' may be officially launched both by the States and by the Centre.

5. Since Science teaching is a new thing to our primary school teachers special re-orientation courses may be organised in each state at convenient ^{and} distinct levels to train them both in the contents and the methodology of primary school science.
6. Suitable handbooks for teachers may be prepared and published by the departments of Education thus assisting the teachers ⁱⁿ ~~in their~~ work.
7. Refresher courses may be organised in every High School and Training Colleges to provide increased training facilities for teachers who are in service to equip themselves with the necessary experience to teach the new subject in their schools.
8. In the undergraduate training Institutions 'methods of teaching Science' may be included as a subject of study instead of 'methods of teaching Nature study'.
9. In the undergraduate training Institutions the teachers under training may be given training in ~~theoretical~~ laboratory craft.
10. Primary school science programme may be recognised as the foundation for the production of scientists, research workers, technicians and technologists whose services are so essential to build the nations industries and economy.
11. The country may realise the importance of locating science talents among the primary school children and try to sponsor a scheme for conserving science talents.
12. The Central Ministry of Education may organise Extension service departments ^{for primary education} all over the country to co-ordinate and improve the

standard of instruction in general and the level of science in particular. This scheme may be provided on the same line as the departments of Extension service are organised for secondary education.

ii. Science Education at the Secondary School Level:

- 12(a) The present restricted course of compulsory science in secondary schools including only physics and chemistry or physical science with a little of biology or human physiology may ~~wider~~ be replaced by a wider course of general science which may include topics freely drawn from all branches of science.
13. The basic syllabus in general science may be adapted to the varying ability of pupils either by increasing or decreasing the depth of the subject ^{of} study. To facilitate this adaptation there is need for providing opportunities to the children to take up examinations that are designed to measure different standards of achievement. There ^{fore}, the schools may be allowed freedom in the choice of selecting the examination Boards. There is need for organising several examining Boards with differing emphasis and standards.
14. Specialisation in science may commence from the 9th grade or the 14th year of age. The course of science intended for specialisation need not be narrow from the beginning. Rather it must be a broad course including combinations of as many branches of science as possible.
15. The size of the science class for purpose of instruction, may be reduced to twenty-five or thirty so that it may be possible to

provide individual attention and adequate activities to the children in the class.

16. Science lessons may be spread over double periods, facilitating to combine theory and practical work. The first half of the period may be devoted for activities or experiments and the second half for the theoretical development of the topic.
17. Pupils who are backward in science may be identified and their specific weaknesses may be diagnosed by administering diagnostic tests. This may be followed by remedial teaching by employing suitable technique.
18. Pupils may be properly guided in the work of taking class notes in the early stages of the secondary school, so that they may be able to take down notes in the later stages without the teachers' assistance. Pupils' class notes may be examined by the teacher once or twice in the year to assure that they are following the instructions given in taking class notes.
19. A common laboratory may be designed and equipped for teaching general science. This may serve the purpose of both lecture demonstration and practical work. Separate laboratories however may be required for the pupils' practical work with regards to the elective subjects.
20. State departments of education may set up convenient designs and plans for the secondary school science laboratories and wherever school buildings are constructed the standard designs may be followed.
21. Standardised aptitude tests may be constructed in each of the regional languages to predict pupils' success in the subject.

On the basis of the results of administering these tests combined with the teachers' estimate, pupils may be guided to select science as an elective subject. This scheme may also serve the purpose of identifying pupils gifted for science education. Provision may be made to provide the ^{suitable} with/opportunities and to conserve such talents and interests in science.

22. As far as possible, general science for every class in the school, may be taught in one method as one subject. To facilitate the science teachers to acquaint themselves with the newer aspects of the content side, refresher courses may be organised by the University departments of science.
23. The teachers may have an off period before every science class to facilitate them to set up apparatus and appliances for the class. This can be done without much affecting the general scheme of work.
24. The syllabus in the science courses may be kept up-to-date by periodical revision. Sufficient and suitable activities may be included to enrich the science course.
25. Science being a rapidly growing subject it is possible to include in the syllabus only the essential aspects of the subject. Yet the pupils will have to know a lot of other aspects of science. This aspect of the background knowledge in science may be provided through suitably organised courses of radio and visual education.
26. The various community resources where the application and impact of science can be observed may be made use of to help the pupils to understand how science is being used in the task of improving human affairs and in controlling nature to the needs of man.

27. Pupils may be encouraged to organise self-help clubs in schools thus providing opportunities to engage themselves in worthwhile activities on the one hand and to promote their personal interests through the development of scientific habits.
28. Science classes may be inspected by the subject inspectors so that the teacher may have the benefit of their criticism and advice and guidance to improve his work.
29. New type ^{tests} may be included both in the secondary level and in the public examinations. Pupils' class work and practical records ^{be} may be evaluated and the marks obtained may be taken into account while deciding their promotion or pass in the examination.
30. Teachers may have freedom to teach the subject in their own way so that there may be scope for experimentation and research.
31. Closer co-operation may be established between the high school science teachers and the various science departments of the University on the one hand and the Teachers' Training Colleges on the other. This will help the science teachers to acquaint themselves with the newer developments in the contents and in the methodology of the subject.
32. While prescribing the syllabus for the secondary school certificate examination the science teachers as well as the University ^{and those from the Teachers' Colleges} representatives from the various departments of science may be included in the committee ^{to be constituted for the purpose.}

iii. Science Education at the University Level:

34. General Science may be included in the courses of studies at the degree level as one of the major subjects with a view to turn out prospective teachers who can handle general science in the secondary schools.

35. A course of general science as part of general education may be included for all those non-science specialists at the degree level with a view to make them more scientific.
36. The existing different science courses for the science specialists may be enriched by the inclusion of core topic of science of a general nature to enable science specialist to understand and appreciate the human endeavour underlying its development as well as its methodology and the role it has played in the evolution of human civilisation.
37. The study of science either as a subject of general education or as an item to enrich and broaden the narrow field of specialisation, may extend over the greater part of the degree course.
38. The present lecture method of teaching science in the degree classes may be adapted to some extent at least, in the early years of the course, with provision for interrogating the pupils and even permitting them to ask questions wherever they find it difficult to follow, so that there may be an easy transition from the secondary school science teaching technique to the College technique of teaching science.
39. Science students at the degree level may be assisted in their study by a well planned system of tutorial instruction. Students may be asked to go for tutorial classes in small groups of five to six.
40. At the post-graduate level better attention may be paid not only to organise research in the several basic sciences but also to train them in the methodology of basic science research.
41. Seminars and workshops may be organised as newer techniques of studying at the research level, particularly while studying

problems that admit such techniques.

42. The existing ~~some~~ maritime Universities of India may organise centres for the study of marine biology, particularly marine embryology and marine physiology. *Newer ones may also be organised.*
43. Special short term courses for the University science lecturers may be organised in the maritime Universities to train the staff members of the departments of biology of the several inland Universities.
44. Courses in biological sciences at the degree level may be enriched by including more topics of marine life. The study of marine biology in one or the other marine biological centres for one month may be made compulsory for all students of biological sciences.
45. In view of the increasing role some of the border-line sciences have commenced to play in the social and economic life of the nation, better provision may be made to organise study and research programmes at the post-graduate level in the case of several border-line sciences.
46. In view of the rapid increase in the number of students taking up science courses in the Universities and in view of the unsatisfactory standard of achievement in science subjects in the degree course, science departments may be better staffed and the science laboratories may be better equipped.
47. The University Grants Commission may keep ready standard laboratory plans and designs, and while extending grant, may insist ^{upon} the Universities to conform to the standard designs and plans so that proper provision may be ensured for the students practical work and post-graduate studies and research work.

iv. Science in Professional Education:

48. In addition to the related basic and applied sciences provision may be made in the different professional and technical institutions to provide adequate general education in science. This is found necessary for all the technicians and the technologists as they have not merely to work in their professional and industrial field, but also to participate effectively in shaping the future of the industrial civilisation, based on science and technology.
49. With a view to develop overall principles and philosophy among technicians and technologists who have to imbibe themselves with a sense of social responsibility, an appreciation of social values and relationships and ~~disciplined~~ powers to see realities without prejudice or blind faith, a course of general science with topics that deal with the part the particular profession or industry has played in shaping the human civilisation may be included. This course may be so framed as to bring out the historical perspective of the particular profession in shaping our civilisation. This perspective should be in its turn to develop in their mind the overall principles and philosophy essential to reorient the operations of the profession such as to promote and to guarantee the welfare of mankind in the present and the future.
50. Closer relation may be established between the post-graduate sections of the professional institutions and the several post graduate science departments of the Universities to facilitate fruitful research work in the field of applied science and technology.

v. Science in Social Education.

51. All the recognised and grant earning adult or social education institutions in the country may be asked to include some aspects of general science in their programme. They may be further insisted to see that the other items of their educational programme will not be directed to inhibit the growth of the spirit and outlook of science.
52. The Adult Education Committee which is one of the wings of the Central Advisory Board of Education, may take up the work of co-ordinating the programmes of the various organisations engaged in Adult and Social Education in such a way as to ensure the inclusion of general science in their programmes and to see that their other programmes will not inhibit the growth of scientific spirit and outlook among the people.
53. The Central Ministry of Education may prepare a standard course of general science for the different levels of social education.
54. Suitable literature in general science may be prepared by the States in their respective regional languages to popularise science among the adults.
55. The states with the assistance of the Centre, may organise particularly in the rural area, science fairs, science exhibitions and science film-shows to promote understanding among the adult mass the importance and the role of science in the present day living.
56. Excursions may be organised by the agencies of adult and social education to places of scientific and industrial concerns to develop in the minds of the adults an appreciation of science as well as the work of scientists.

57. In addition to the literary medium of instruction the other modern media like radio, films, exhibition, ~~science~~^{fair}, demonstrations and displays etc., may also be employed in providing science education to the adults.
58. The States as well as the Centre may encourage newspapers, journals and periodicals to include topics on general science. Prizes may be instituted for those papers that best serve the cause of science education, at different levels.
59. The several state and central departments of public utility ~~that~~ make use of science for the benefit of the people may be requested now and then, to popularise how science is being made the basis of their work. They may also be asked to distribute suitable literature, thus contributing to the education of the people in general science.
60. The recently started Community Project Centres may try to include in their programme some aspects of imparting general science as ~~the~~ means to wipe out superstitions among the unsophisticated villagers and to develop a scientific outlook. They may also try to popularise scientific habits and ways of living.
61. Libraries intended for the general education of the adults may be equipped with good books written in the regional languages to popularise science.
62. Lectures and lecture courses in science may be organised in different parts of the country according to a prepared plan for the benefit of adults. They may be designed in three different standards to suit the ^{three} classes of adults, namely, the newly made-literates, the literates and the educated adults. These lectures

may be organised by the State departments of education, the state adult education organisations, the Community Project Centres, etc. The Central and State Ministries of Education as well as the University departments of science may sponsor and assist the scheme of science lectures and lecture courses with technical experts and financial aid.

vi. Science in Teacher Education.

REORGANISATION OF TRAINING COLLEGES BOTH AT THE
POST-GRADUATE AND AT THE UNDER-GRADUATE
LEVELS:

A. At the Post-Graduate College Level:

63. The Science methodology in the Teachers' Colleges may include
 1. The actual study of teaching various topics of science;
 2. The preparation for the teaching units by individual trainees followed by discussion of the same by the group; and
 3. Tutorial work on the methods of teaching.
64. Provision may be made in the Training Colleges for the trainees to get experience in the laboratory art-craft as a compulsory aspect of the training course. To facilitate this item, the Colleges may be equipped with suitable laboratory facilities.
65. Particular attention may be paid by the Teachers' Colleges to provide the trainees with the practical experience of preparing various teaching aids and in the micropreparation techniques.
66. At the post-graduate level, Diploma in Teaching Science may be instituted after the B.Ed. Course. Diploma holders will be better fitted to teach science than Bachelors or Masters of Education.

67. Block practice of teaching, atleast for one to two weeks, may be introduced on the practical side, to provide all aspects of experience necessary for a science teacher.

Greater weightage in terms of marking may be given in the Examination for the practical side of work done during the Course, by ~~the~~ Pupil^{be}Teachers.

B. At the Under-Graduate Teachers' Training Level:

68. The present period of one year for training teachers for the primary schools may be increased to two years atleast and the courses may ^{be} reorganised to suit the two years training course.

At present, there is no provision for teachers to study the subject proper in the Training Colleges, except in those meant for the training of 'Vernacular Teachers'. It is essential to devote the second year of the Training Colleges mainly for studying some of the school subjects to be taught, to an advanced level. This will also help the teachers to equip themselves with academic experience so that they may be able to work as effective teachers even in the upper classes of the Primary schools.

69. Better facilities may be provided to train teachers in organising science clubs, excursions, field trips and in the work of preparing some of the simple aids for the demonstration of experiments.
70. Lectures may be organised to enable them to understand the progress of science.
71. Adequate provision for the inservice training of teachers may also be made. The High schools and Training Colleges, may try to

start short period science courses for the benefit of teachers in the primary schools. If an 'All India Council for Primary Education' is to be started, it may be possible for the Council to provide training facilities to teachers in primary schools.

72. Teachers' Colleges training teachers at the post-graduate level, may try to start certificate courses in science teaching. At present, Master's Degree in Education may also provide opportunity for studying one subject or the teaching of one subject to a comparatively deeper level. But the number of teachers taking this course is very small. Rarely a teacher selects teaching of science as a subject for his Master's Degree Examination. Moreover, this course extends over a period of one or two years and hence does not encourage many teachers to take up the course. Further, admission facilities in the Universities for Masters' Degree course are also limited.

If Diploma and Certificate courses are started particularly in the Teaching of Science, a good number of teachers can register themselves either as full-time students or as part-time evening students. Hence the trained teachers can increase their capacity as science teachers if such ~~of~~ courses ~~are~~ instituted in all the post-graduate Teachers' Colleges.

in addition to his B.Ed.

A teacher with a diploma or a certificate in Science Teaching [^] will certainly prove a better science teacher than a science teacher with a B.Ed. or B.T., or L.T. degree. ~~in Education.~~

C. Need for Providing increased Training facilities for
Teachers in Service

73. Science teaching techniques are fast changing along with the

progress of educational theory and practice. In addition to this the nature of science contents is also changing as a result of research studies in the field of basic science; and teachers in teaching that subject, require further education and training. We have to meet this need only through an effective provision for the in-service teacher education. The newly started Advisory Council for the Secondary Education can tackle this problem to some extent through the Departments of Extension Service which are spread all over the country. But this is mainly intended to serve the cause of secondary education. Science teaching at the primary school level is equally, if not more, important. So a new All India Organisation of the Nature of an Advisory Council for Primary Education is also necessary. Let us hope that such a Council will soon be formed. Meanwhile, a scheme of inservice education for teachers, which can be possibly launched within the existing facilities is herewith furnished. ~~will be~~ Of course, the provision is to be under two catagories, viz., the content side and the ~~professional~~ side:

1. CONTENT SIDE:

74. Summer or Short Vacation Courses may be organized by each of the Science Departments of the Universities to provide regular and systematic education in the subject, particularly in the field of newer developments.
75. The Departments of Extension Service may arrange a series of lecture programmes at intervals and at different selected centres, to provide teachers in those localities, education regarding the newer developments in the subject.

76. Professional bodies similar to the Science Masters' Association of England and Science Education Society of America may be organised on a national scale and their branches may be started in each state. This may be recognised by the Central Ministry of Education as a non-official co-ordinating body, with regard to science education and the required financial help may be extended to the organisation. This organisation according to a planned programme may arrange lectures in each state at convenient centres on the progressive aspects of science.

ii. PROFESSIONAL SIDE:

77. The Teachers' Colleges may organise short courses and lectures particularly on the newer trends in science teaching.

78. Seminars and workshops may be organised in Teachers' Colleges to provide facilities to try the newer techniques of teaching the subject, ^{and for} preparing the aids, constructing the tests, organising correlated activities etc.

iii. The departments of Extension Service may also take up the above two items and try with the experts they could get from the Teachers' Colleges and other sources.

Separate Departments of Extension Service for primary education may also be organised. That may help primary school teachers to get the guidance and assistance in acquainting themselves with the newer methodology of science teaching.

79. Colleges of Technology may run special courses for science teachers in the following fields:

- a. Glass blowing, glass welding, glass bonding and making other glass apparatus.
- b. Use of optical aids.
- c. Preparation of certain aids like microspecimens, preserved specimens, stuffed specimens, films, filmstrips and slides.

80. Teachers of Science in all schools may have increased facility to get and study the journals that are devoted for the cause of science and science teaching.

vii. Organisation^{al} and Administrative Aspects of Science Education:

81. The Central Ministry of Education may maintain adequate expert staff, for providing technical assistance to the states particularly, on matters related to newer faces of development in science education.

82. The Central Ministry may take the initiative in organising a 'National Union of Science Masters' on the lines of the Science Masters Association of England. This organisation will actively participate both at the Central and ^{at the} State Levels in the work of maintenance and improvement of the standard^{of} science instruction.

83. The Central Ministry of Education may bring out a 'Handbook for Science Teachers' in English and Hindi and assist the state Governments to bring out translated or adapted editions of the same in the respective regional languages.

84. The Central Ministry of Education may publish periodicals, journals and pamphlets in English and in Hindi to acquaint the teachers with the progressive aspects of science education at different grades of instruction both in its contents and in its methodology. The state governments may be assisted to bring out translated versions of the same in the respective regional language

85. The Central Ministry may organise a 'National Committee for Research in Science Education' and recognise its status as equivalent to those of the several national laboratories. This organisation in co-operation with Central Institute of Education and the proposed 'National Union of Science Masters', may try to organise, conduct and co-ordinate research work on problems related to science education.
86. The Central Ministry of Education may sponsor the organisation of a 'Central Laboratory workshop' for the manufacture of articles of laboratory equipment, apparatus and appliances required by the Schools and colleges in the different states.
87. Along with the growing industrialisation of our country, the importance of Science Education is increasing day by day. This naturally necessitates to pay greater attention to science teaching in our schools. In this connection if experienced science teachers are appointed as subject inspectors they can visit and inspect schools guiding science teachers in their work. The Central Ministry in co-ordination with the state department of Education and the Universities may take up this work of providing expert guidance to science teachers through the appointment of subject inspectors. This will go a long way to improve science teaching in our schools.
88. In addition to the appointment of subject inspectors in science there is need for the state department of education in each state, to maintain an expert science educator to advise on matters related to science education. He must be entrusted with the work of suggesting suitable plans for science activities in the school,

School science block, laboratory organisation and equipment, science curriculum, text books, their preparation and selection, etc.

89. At present the research work on certain aspects of teaching science is being done in Teachers' College and the Central Bureau of Text Book Research. The teaching of science presents different problems in different states. So, there ^{is} need for each state department of education to have its own research section. Recently the New State of Mysore has started a Bureau for educational research and this Bureau in addition to other problems, can certainly take up the study of problems related to the teaching of science. Hence it is essential to start such bureaus in every state.
90. The Scientific and Technical Education Division of the Central Ministry may constitute an expert committee to prepare a hand book of suggestions for science teachers. This may be published in English and Hindi. The state departments of education may be asked to translate it into the regional languages, if necessary, with suitable alterations to suit the particular needs of the state. This will help the teachers, particularly, in their daily work of teaching and guiding pupils.
91. Though the Central Government has sponsored various schemes and competition for the production of children's literature, real effort is not forthcoming in the direction of producing good science literature for children. The state governments may think of more deliberate schemes to produce suitable reading books in science for the different age groups in their respective regional languages.

92. Generally it is found that the laboratories in aided institutions are not adequately equipped. Even the Government school laboratories require better equipment and management. The state governments may try to conduct a survey of the position of laboratories and on the basis of the report of the survey, try to improve the position with liberal financial grant for their equipment and maintenance.
93. Science is progressing rapidly with regards to its informational wealth. This necessitates that our teachers should also know them. Our text books must also incorporate all the new developments in the field. Therefore, there is need for publishing, specially for teachers and text book writers, a journal devoted to popularise the progress of science. Since it is the regional language that dominates in the school line, each state may try to publish a quarterly journal on the development of science in the respective regional language. The state departments of education may undertake this work in co-operation with the University Departments of Science on the one hand and the Central Ministry for Scientific and Technical Education, on the other.
94. A library of science books may be organised in large cities and in all the District Headquarters. Text books and general books in science, published in English, Hindi and the regional languages may be kept there. Schools and teachers may be permitted to borrow them. Similarly, apparatus and appliances may also be kept. Some of the schools may not be able to buy a good number of costly instruments and apparatus. Those schools may be permitted to get the particular apparatus from the Central

Library and use it for their class-room purpose and return it later.

Similarly, a Library^{of} science films may also be organised. Teachers can borrow the particular films required by them for class-room purpose.

The above services will be more effective and of far-reaching results if regular arrangements are made to supply and collect books, apparatus, appliances and films to and from schools as and when they are required.

APPENDIX I.

PHILOSOPHICAL BASES OF SCHOOL EDUCATION.

A. Whewell and the Place of Science in a Liberal Education.(Page 103).

We have seen how Whewell took up the cudgels on behalf of Cambridge at the time of the attacks of the Edinburgh Review. Whewell's balanced arguments were certainly the outcome of a consistent view of the aims of education for, like all other writers on education of his day, he judges the value of the various subjects in the curriculum from the point of view of the mental training they afford. The disciplinary view commended itself particularly to the austere Master of Trinity.

Whewell identifies a liberal education with the higher education provided for the upper classes, upon whom, he considers, the prosperity of the community depends. What a comforting and complacent view. He distinguishes between permanent and progressive studies. Among the permanent studies he includes the ancient languages and established branches of mathematics such as geometry and mechanics. He applies the epithet progressive to the comparatively modern sciences of chemistry, botany, geology, etc. He considers that both kinds of study should be included in a liberal education, but that the permanent studies must be taken first. Whewell would administer the powder before the jam.

One of the adverse criticisms of the writers in the Edinburgh Review was that Cambridge clung to old geometrical methods in the teaching of mathematics and neglected the newer analytical methods. Whewell is eloquent in his defence of geometrical methods as giving a training

in reasoning. He tells us that analytic methods are mechanical. We are carried along "as in a railroad carriage entering in at one station and coming out of it at another, without having any choice in our progress in the intermediate space". With geometrical methods, on the other hand, the student is not borne along in this comfortable fashion. He has to think out each step, to refer to what has already been proved and be able to survey the whole problem from different angles. Whewell concludes that the character of the reasoning involved accounts for the success of mathematics in having trained many eminent lawyers.

When the mind of the student has been trained by the discipline of the permanent studies, he may give his attention to other subjects. Whewell considers that chemistry, though indispensable in the professional training for medicine, is not sufficiently systematized to form a good subject of study for students. Indeed there were but few general principles in chemistry at that time. He would have the young men learn the established sciences, such as astronomy and mechanics, where the conclusions can be rigorously tested. He maintains that criticism and argument belong to the mature philosopher and that students at the university must learn to submit to authority. If allowed to express their opinions instead of "quietly forming their minds for future action". Whewell fears that they will become shallow and conceited. They must learn to judge the value of different hypotheses in those established subjects where there can be no difference of opinion. Hence the permanent studies must come first - Rules must be learnt before reasons. Thus Whewell suggests that the various branches of mathematics and physics will supply the necessary disciplin

and that afterwards the student may proceed to chemistry, botany, etc. There is hint of the stern pedagogue behind all Whewell's arguments.

However, Whewell looks beyond the needs of the undergraduate and shows the value of a rich knowledge of science in a wide scheme of education. He maintains that the progressive studies, since they involve discovery, exert a profound influence upon education. He discusses at length the influence of the scientific discoveries of one period upon the intellectual outlook of the succeeding period. He goes so far as to assert that "every great advance in intellectual education has been the effect of some considerable scientific discovery or group of discoveries". As we should expect, the historian of the Inductive Sciences makes a great point of the careful study of the work of the great investigators of the past - he urges the introduction of questions on the history of science into Tripos examinations and the giving of optional lectures at college on the historical development of science and on recent achievements in the progressive sciences.

Whewell's words were as the voice of one crying in the wilderness: Men did not heed him because the great battle waged on behalf of science had not begun. Whewell's methodical arguments were not sufficiently resounding to make themselves heard in the great world outside the universities. Science needed a vigorous champion who could appeal to the multitudes. Such a man was Herbert Spencer.

- D.M. TURNER.

B. Herbert Spencer and Education for Complete Living. (1889-1903).

Herbert Spencer (1820-1903) may be regarded as the philosopher of the scientific movement of the second half of the 19th century. He chose the term evolution to denote his hypothesis, which was an attempt to combine the notion of the derivation of existing plants and animals from simpler ancestors with that of the nebular theory of the universe. Spencer's extravagant generalizations found acceptance in an age that believed in progress and in its own sufficiency. His cry for the need of science in education found a ready response and his teachings were accepted, not from the intrinsic value of his arguments, but because of his recognized authority in other fields.

In his main work on education Herbert Spencer begins with the question "What knowledge is of most worth?" In his customary fashion he refers back to primitive customs and describes the love of ornament and display shown by the Orinoco Indians. He then points out that the same love of display is shown in contemporary education. In the curriculum he explains that it is not what knowledge is of most worth that receives consideration but what knowledge is most imposing and most likely to bring applause. The shams of fashionable education, and in particular the accomplishments of young ladies, invoke his stern disapproval.

Herbert Spencer classifies the activities of life under five heads. (1) those which directly minister to self preservation; (2) those which by securing the necessities of life indirectly minister to self preservation; (3) those activities which have for their end the rearing and discipline of offspring; (4) those which are involved

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in the maintenance of proper social and political relations; (3) those miscellaneous activities which fill up the leisure part of life. Spencer's ideal education is one which shall train adequately in all these directions and thus prepare for complete living. He therefore maintains that the aim of education must be to give a "due proportion" between the degrees of preparation in each of the sciences. He applies his classification of the activities of life to the problem of the school curriculum.

Spencer distinguishes between the two values of every intellectual acquirement, (1) knowledge, (2) discipline. In his discussion of the disciplinary value of scientific studies he takes refuge in the asylum ignorantia and baldly states that the acquirement of "facts most useful for regulating conduct involves a mental exercise best fitted for strengthening the faculties. It would be utterly contrary" he says, "to the beautiful economy of Nature, if one kind of culture were needed for the gaining of information and another kind were need as a mental gymnastic". Having disposed of an age-long problem in this simple manner he proceeds to show that the discipline of science is superior to that of ordinary education because of the religious culture which it gives. True science, he maintains, is religious because it gives the student a faith in unchanging relations "in the invariable connection of cause and effect and in the necessity of good or evil results".

Herbert Spencer writes with such conviction that it is clear that he felt some moral effect resulting from the operation of physical forces. His writings reveal the characteristic 19th century attitude towards the inexorable laws of nature, but the confusion of ethical principles and the Rousseauian discipline des choses seems peculiar to him. Spencer's claim for science was primarily on the ground of its utility. This aspect no doubt commended itself more than any other at a time when the applications of science were receiving recognition on all sides. The very exaggeration with which he illustrated his arguments compelled attention.

C. Huxley and Retrospective Prophecy.(Page 103)

The course of science was platted in far reasonable tones by T.H. Huxley. Even the most conservative upholders of the classical regime were ready to admit that science is useful. Huxley sought to show that science is beautiful. The sunny side of his philosophy was revealed in his plea that children should be led to love nature and to follow her ways in joyous pursuit. Huxley's personification of nature leads him to regard nature as an educator. "Nature's discipline", he says, "is not even a word and a blow, and the blow first; but the blow without the word. It is left to you to find out why your ears are boxed.....The object of education.....is to make good these defects in nature's methods, and prepare the child to receive nature's education.....without waiting for the box on the ear".

Beginning with Voltaire's story of Zadig, the wise man of Babylon, Huxley shows that retrospective prophecy is a marked characteristic, nay, a definite function of astronomical science. He quotes the well-known statement of Airey that an eclipse of the sun was visible in Lydia on the afternoon of 28th May in the year 585 B.C. Huxley points out that such a statement cannot be verified, but that since the methods which astronomy uses when working forward lead to correct results, the same methods are trustworthy in working backwards to results not directly verifiable. This argument leads Huxley to his main thesis, namely, that the methods of retrospective prophecy are legitimate for other sciences since the method depends on what he calls the "fundamental axiom of the constancy of nature" which is the "common foundation of all scientific thought".

Throughout his Essays Huxley emphasizes the different culture resulting from a knowledge of science and hence he upholds and the need for science in education. He shows how the history of science reveals the growth of the conception of causality. The enormous development of scientific knowledge during the 19th century led Huxley and other men to rely too much on what they conceived to be the methods of science. While retrospective prophecy might lead to the reconstruction of events seemingly as real as those due to our immediate senses in reactions, yet Huxley did not admit that the interpretation of past and immediate events depends on the use of certain instruments of thought which themselves require critical examination. It was not until after his time however, that the serenity of men of science was disturbed by such doubts.

- D.M. TURNER.

D. Some Fundamental Principles Formulated by the Committee
of the National Education Association of America. Ref. Page 158

1. The fundamental purpose of all teaching of science in all grades of schools is to foster the development of the true scientific spirit.

2. Since all normal children are endowed by nature with the elements of the scientific spirit, the purpose of science teaching is accomplished most successfully when the science classes merely furnish an environment in which the scientific spirit can grow from the crude and instinctive childish form into the more finished and logical adult form.

3. The scientific spirit is characterized by three equally important elements; namely: (i) A desire to understand more fully the meaning and uses of things, leading to the definition of problems concerning the meanings and uses of things. (ii) A firm faith that the solution of these problems is worth while and possible. (iii) A method of thinking that leads to the most expedient and useful conclusion. A science teaching that fails to recognize in practice all three of these elements is necessarily defective.

4. The most effective method of science teaching yet devised, in which all three of the elements of the scientific spirit receive due recognition, is called the method of teaching by projects.

5. Every project is characterized by three equally important elements, which are coordinate with the three elements of the scientific spirit; namely (i) A desire on the part of the pupil to understand better the meaning and use of some fact, phenomenon, or experience. This leads the pupil to ask question. (ii) A firm faith that it is worth

while and possible to secure a better understanding of the thing in question. This causes the pupil to go to work with enthusiasm.

(iii) The gathering from experience, books, and experiment of the needed information, and the application of this information to answer the question in hand. This settles the question temporarily at least.

6. Any question that one takes concerning the phenomena of nature and of life is a legitimate basis for a project.

7. A project differs from a topic in that (i) a project originates in some pupil's question, and not in an adult's logical sequence of ideas. Its implications need not, therefore, be confined like a topic to any of the arbitrary divisions of science, such as physics, biology, etc., which have been devised for intellectual convenience of adults. (ii) The project involves the active and motivated participation of the pupils in carrying it out. It does not, therefore, like the topic, lend itself to didactic, formal treatment in which the teacher does all the thinking and the pupils passively absorb. (iii) The project never ends in a complete, final or absolutely finished conclusion. It is, therefore, far less likely than is the topic to leave the pupil with the idea that he has heard the last word on the subject. It leaves him open-minded.

8. In the project method the outline and backbone of the course is derived from the spirit of science, whose growth it aims to foster. The organization of the work depends on the skill of the teacher and the enthusiasm of the class. It need not, therefore, be constrained like the topical order to the narrow bounds of the arbitrary classifications which the adult specialist has found convenient for his own intensive work.

9. The project method of teaching when well done leaves the pupil with a well-organized mass of useful information and a love of the scientific spirit which will lead him to continue to acquire more. This entire discussion arises from the fact that the logical topical method has failed to do just this.

10. The present need of the schools is for a large collection of sample methods of treating a given project, which could be used in showing teachers in a given community how to devise and utilize projects adapted to different grades of pupils in their own environment. This the committee is now making. It would be foolish and fatal to the success of project teaching to try at present to divide the high school time into conventional sections of one year of biology, one of physics, etc.

APPENDIX II.

Samples of Courses of Studies in Science.

Ref. Page 204, 1950.

SAMPLE I.

Syllabus in General Science prescribe^d by the Bristol University School Examination Board. The whole Syllabus is intended for those ^{type} select General Science as an Additional subject. Syllabus in Ordinary type is intended for all students of the Grammar School.

GENERAL SCIENCE SCHEDULE.

No two teachers will present the subject-matter in the same order and this schedule is to be regarded as an indication of the detail it is desirable to include in the general science.

The subject-matter for General Science is shown in ordinary type, that for Additional General Science is the complete schedule.

No calculations involving the use of formulae will be expected in the General Science paper.

I. THE SOLAR SYSTEM.

The place of the Earth in the Solar System, and of this in the Universe. The Universe in outline: stars, comets, meteors, nebulae, Milky Way, constellations. The Sun as the nearest star. The sun-structure and size; sun-spots: corona. The Solar System in outline, with some idea of distances. Planets: satellites. The Moon; size,

distance, phases. MEAN SIDEREAL DAY. BRIEF HISTORY OF TIME MEASUREMENT. THE LAW OF THE SIMPLE PENDULUM CLOCK. Gravity as a cohering force. THE MOON AND TIDES.

2. The Sun as a Source of Radiation (Light and heat).

METHODS OF DETECTION OF RADIATION; ORDINARY FORMS OF RADIATION AND RADIATIONS (INFRA RED, ULTRA VIOLET). METHODS OF PRODUCTION (QUALITATIVE, e.g. IMPORTANCE OF BODY TEMPERATURE).

3. Wave Motion and Sound.

SIMPLE CONCEPTIONS OF TRANSVERSE AND LONGITUDINAL WAVE MOTION; WAVE LENGTH, FREQUENCY, VELOCITY. SOME IDEA OF THE FREQUENCIES OF CHARACTERISTIC FORMS OF RADIATION. VELOCITY OF PROPAGATION OF SOUND; RANGE OF AUDIBILITY. NATURE OF SOUND; SOUNDING BODY VIBRATES, ECHOES. PRODUCTION OF SOUND; VOCAL CORDS, INSTRUMENTS, SOUND SPEAKER. PITCH AND FREQUENCY. THE HUMAN EAR. DOPPLER EFFECT. SOUND RANGING.

4. Light.

Source of light, development of methods of illumination (note reliance on the necessity for a high temperature). Rectilinear propagation of light; eclipses, shadows. Regular and irregular reflection; reflection at a plane mirror; laws of reflection; position and character of the image; paths of rays of light whereby the image is seen. ROTATION OF MIRROR; SEXTANT. Reflection at concave and CONVEX surfaces; construction of the image position; real and virtual images. Refraction at plane surfaces; critical angle. Deviation by a prism. Dispersion; composite nature of white light; recombination; colour mixing by addition and subtraction. Convex and Concave Lenses. Graphical methods of finding image position and size. The camera. Projection of real image by convex lens. The human eye; simple structure; DEFECTS OF VISION

ACCOMMODATION INCLUDING LONG AND SHORT SIGHT. MICROSCOPE AND SMALL TELESCOPES. SIMPLE IDEA OF LIGHT STANDARDS AND INTENSITIES. SIMPLE PHOTOMETER. PHOTOELECTRIC METER. INVERSE SQUARE LAW. CANDLE POWER FOOT CANDLE. SOME IDEAS OF RECOMMENDED INTENSITIES OF ILLUMINATION.

5. The Earth's Crust.

Formation of earth's crust; evidence of the state of the earth's interior; hot springs, volcanoes. Minerals; definition; a few of the commonest types (e.g. quartz, calcite, mica, feldspar). Geological meaning of the word 'rock'. Groups of rocks; igneous, sedimentary, metamorphic; chief characteristics of granite, basalt, chalk and other limestones, conglomerate, sandstone, clay, shale, slate, coal. USES OF ROCKS PARTICULARLY AS BUILDING STONES. Raised beaches; submerged forests. Inclination of strata; folds; faults, unconformity. Water, wind and ice as agents of denudation and transport. Stratification; general sequence of animals in earth's history. ores: definition; IRON (ORIGIN OF HAEMATITE, ZINC BLEND, SALT (Salinity of sea), Bauxite. ORIGIN OF COALS; OCCURRENCE; METHODS OF MINING (UNDERGROUND AND OPEN CAST). OIL ACCUMULATIONS IN NATURE; OIL WELLS. Soils and subsoils; methods of formation; content (Particles, water, air dissolved materials properties (Porosity, water holding capacity, temperature, binding capacity).

6. The Atmosphere.

Air has weight and exerts pressure; pressure and force; simple barometer, aneroid and barograph; simple applications. AIR POLLUTION. Uses of air pressure. Boyle's law. Water vapour in the atmosphere; evaporation; saturation; humidity; dew point; cooling by evaporation. Decrease in temperature with height, cooling by expansion. Clouds, mist

fogs. TYPES OF CLOUDS. WET AND DRY BULB THERMOMETER. STILL HYGROMETRY; HAIR AND PAPER HYGROMETERS. NATURAL CAUSES OF ATMOSPHERIC PRESSURE; CYCLONE AND ANTICYCLONE; DEPRESSION; ISOBARS; WEATHER MAPS. Composition of the atmosphere; oxygen, nitrogen, carbon dioxide, inert gases: air as a mixture. Liberation of oxygen from mercury oxide: properties. Preparation from air of nitrogen; properties. Carbon; simple forms and uses. Oxidation and reduction. Reduction of an oxide by heating with carbon; extraction of iron and zinc.

7. Water.

Sources of water: natural waters. The water table. Water pressure; water finds its own level, pressure and depth; the water supply, water towers, reservoirs; water pumps. Transmission of pressure in water. Water as a solvent. Simple estimation of solubility. Effect of temperature (qualitative). SOLUBILITY AND TEMPERATURE. Filtration. Crystallisation. Some other solvents and their uses. Simple study of dialysis and osmosis in their relation to biology. The states of water. Distillation. The water cycle in nature. Boiling point and freezing point; THE QUALITATIVE EFFECT OF PRESSURE AND OF DISSOLVED SOLIDS ON THESE. Composition of water (qualitative); synthesis from hydrogen and a metallic oxide; production by combustion of hydrogen; preparation of hydrogen from steam and iron; properties. HYDROGENATION OF OILS AND COAL. THE IDEA OF THE REVERSIBILITY OF SOME CHEMICAL ACTIONS. Simple study of density: direct determination with the use of large quantities and spring balances. Experimental study of flotation; comparison of weight of water displaced with that of the displacing body. SIMPLE HYDROMETER (e.g. LOADED TEST-TUBE PROVIDED WITH A SCALING). Upthrust;

application to ships, balloons, submarines, cargo carried, Hunsell line Archimedes' principle as a principle of flotation. SIMPLE GRAVITY.

8. Heat Energy. Sources of heat. Types of fuel. Effects of heat; incandescence; chemical action; change of state; change of size (qualitative); COEFFICIENT OF LINEAL EXPANSION. Applications and use of the change in size of solids, liquids and gases. Types of thermometers (including maximum, minimum, clinical); scales. GRADUAL CONVERSION OF CENTIGRADE AND FAHRENHEIT SCALES. Anomalous expansion of water. Heat Units; calorie, B.Th.U., therm. Determination of thermal capacity per gram, or per pound, using thick calorimeters (not more than one heat gain and one heat loss). WATER EQUIVALENT. Meaning of calorific power of fuels and simple costing. Change of state: melting, evaporation and boiling. MELTING POINT FROM COOLING CURVE. Latent heat of steam (thick calorimeters). Latent heat of ice by Black's method. LIQUEFACTION OF AMMONIA, CARBON DIOXIDE AND AIR. SIMPLE TREATMENT OF STEAM ENGINE AND I.C.E. SUPERHEATED STEAM. THE TURBINE. Transference of heat. Rectilinear propagation of radiation. Good and bad conductors; good and bad radiators; ventilating requirements and methods; application to hot water systems; draughtless heating, lagging, clothing. Distillation of coal; simple account of the manufacture and purification of coal gas and of by-products; simple coal-tar products. Simple preparation of carbon monoxide and METHANE. Coal gas and its use; ignition temperature; carbon monoxide as a product of imperfect combustion and its dangerous character; a simple method of detection. FACED GAS, WATER GAS. Alcohol; simple treatment and fermentation.

9. Matter.

DIVISION INTO THREE STATES AND THE CHARACTERISTICS OF EACH; SIMPLE

TREATMENT OF VISCOSITY, RIGIDITY, HAPINESS. METHODS OF FINDING RIGIDITY OF DESIGN, TUBULAR CONSTRUCTION, GUNDER SHAPES, STIFF STRUCTURES AND TRIANGULATION IN BRIDGE AND PYLON DESIGN. ELASTICITY; HOOKE'S LAW; SPRINGS (COILED AND LAMINATED). Simple account of elements, compounds, atoms, molecules. SYMBOLS. SIGNIFICANCE AND VALIDITY. USE OF EQUATIONS FOR CALCULATING WEIGHTS OF REACTING MASSES, GASEOUS and liquid diffusion.

10. Acids and Alkalies.

General properties of dilute acids and alkalies: neutralisation: methods of preparing simple salts. Preparation of carbon dioxide, properties and uses. Extraction of sulphur (omit allotropic forms); properties of roll sulphur and its uses; simple account of vulcanisation. Sulphur dioxide; production by oxidation only of (1) sulphur (2) IRON PYRITES OR ZINC BLENDE; bleaching and germicidal properties; conversion to trioxide, leading to simple manufacture of sulphuric acid by contact process; properties and uses of this acid. The preparation and simple properties of hydrochloric acid and nitric acid. USE OF NITRIC ACID IN MAKING AN EXPLOSIVE AND A DYE. SIMPLE CHEMISTRY OF PHOTOGRAPHY. PREPARATION OF CHLORINE BY OXIDATION OF HYDROCHLORIC ACID (ONE METHOD); PROPERTIES OF CHLORINE IN RELATION TO BLEACHING, ACTION ON SLAKED LIME AND STERILISATION OF WATER. USES OF CARBON TETRACHLORIDE AND CHLOROFORM. Sodium hydroxide as a typical alkali; action on aluminium, salts, fats. THE HABER PROCESS OF PREPARATION OF NITRIC ACID FROM AMMONIA. SODIUM carbonate and sodium bicarbonate; the action of heat on these. Calcium carbonate, calcium oxide and hydroxide; cement and concrete and their importance. Calcium bicarbonate; formation of caves in

limestone country; stalactites and stalagmites. Boiler scale. ESTERS AND THE PREPARATION OF A TYPICAL ESTER.

11. Fabrics.

Appearance; action of heat, acids, caustic soda and bases on animal vegetable, mineral and artificial fibres. PRODUCTION OF ARTIFICIAL SILK BY VISCOSE PROCESS. Dirt removal; soap and the reason for its use; hard and soft water; comparison of hardness by soap solution; removal of hardness. THE PREPARATION OF SOAP.

12. Metals and Alloys.

The uses of iron, copper, aluminium, zinc, lead, tin and their importance in the evolution of civilisation. Alloys; steel, solder, brass, duralumin, bronze.

13. Machines and Work.

Work done when energy is expended; units of work; horse power. The moving of weights by machines; pulleys, levers, INCLINED PLANES, muscles WHEEL AND AXLE, TRAIN OF GEAR WHEELS. MECHANICAL ADVANTAGE; USEFUL WORK AND INPUT WORK. Efficiency. Power, THE RELATION OF THE WATT TO THE HORSE POWER. The mechanical equivalent of heat. BRAKE HORSE POWER. THE LAW OF THE MACHINES. SIMPLE CONSIDERATION OF VELOCITY AND UNIFORM ACCELERATION. FORCE AS CAUSING CHANGE IN MOTION. RECTANGULAR RESOLUTION OF FORCES. FRICTION AND LUBRICATION. CENTRE OF GRAVITY. STABLE AND UNSTABLE EQUILIBRIUM. IDEAS OF STREAM-LINING.

14. Electricity.

A simple account of the properties of magnets; the Earth as a magnet; the compass. Single magnetic fields. The magnetic effect of

a current; comparison of the solenoid and the magnet; electromagnets and their uses; electric bell, telephones, the motor effect, moving coil instruments. THE STRENGTH OF THE ELECTROMAGNET. Current electricity; typical circuit; conductors, insulators, resistance, voltage, and P.D. Ohm's Law and measurement of resistance (Voltmeter-ammeter method only). Wiring in series and in parallel. VOLT-AMPERE-AND-POWER CONVERSION. Units; watts, kilowatt-hour, simple costing. The heating effect of a current; electrical supply and distribution: safety devices, fuses and earth points. THE SIMPLE CELL. LECLANCHÉ CELL. DRY BATTERY. Electrolysis of dilute sulphuric acid and copper sulphate solution; electro-plating. THE LEAD ACCUMULATOR. MANUFACTURE OF CAUSTIC SODA AND CHLORINE. SIMPLE ELECTRIC MOTOR. D.C. and A.C. TYPES. ELECTROMAGNETIC INDUCTION; THE LAWS OF FARADAY AND LENZ. THE DYNAMO. A.C. and D.C. MACHINES. THE TRANSFORMER AND THE DISTRIBUTION OF ELECTRICAL ENERGY. THE INDUCTION COIL.

15. Energy.

Natural sources of energy; the sun, fuels, food, kinetic energy of moving air and water. Transformations of energy, either naturally or by conscious direction. Storage as potential energy (including tide

16. The World of Life.

The life history of the earthworm, an insect, a fish, a frog, a mammal (with special reference to man), ALGAE AND MOSS, and a flowering plant, with special reference to their relation to life in water, air and on land and with so much of their gross structure as is necessary for understanding the major life processes. SIMILAR COMPARISON OF ANIMAL AND PLANT CELLS.

17. The various Activities of Living Things.

Photosynthesis; necessity of chlorophyll, carbon dioxide and light energy; production of starch, evolution of oxygen (by water plants). Necessity of water for the plant; its absorption path through the plant and loss in transpiration; function of root and root hairs. Demonstration of the necessity of mineral substances from the soil and the relation of this to fertilisers. The organic substances built up by the plant; carbohydrates, oils, fats, proteins; these substances as the main food of the animals. A brief account of the more important vitamins and their sources. The use of food substances in body-building in plants and animals. A balanced diet. CONVERSION OF STARCH TO SUGAR BY PTYALIN; OUTLINE OF THE PROCESS OF DIGESTION IN THE HUMAN BODY; ENZYMES IN PLANTS. THE CONDUCTION OF FOOD SUBSTANCES IN THE ANIMAL. Energy supply by respiration; demonstration of carbon dioxide production in human respiration and in germinating seeds. The meaning of growth and development explained with reference to the life history of the frog, and the germination and the subsequent growth of a flowering plant. Reproduction as illustrated by seed formation in a flowering plant and spawning in the frog. Modes of movement. HEREDITY AS THE PRODUCTION OF OFFSPRING SIMILAR TO THE PARENT. VARIATION ILLUSTRATED FOR EXAMPLE BY HAIR COLOUR IN THE HUMAN FAMILY OR BY THE NUMBERS OF RAY FLOWERS IN THE DAISY HEAD. SIMPLE ACCOUNT OF MENDELISM ILLUSTRATED BY THE INHERITANCE OF ONE PAIR OF CHARACTERS INVOLVING DOMINANCE. THE FUNCTION OF THE NERVOUS SYSTEM IN RELATION TO PERCEPTION AND CONDUCTION OF STIMULI AND RESPONSES TO STIMULI. THE ORGANS OF SPECIAL SENSE. REFLEX ACTION. ILLUSTRATED BY REFLEX OF FLICK OF LIGHT. MUSCULAR LOCOMOTOR MOVEMENT IN ANIMAL. COMPARISON OF GROWTH MOVEMENTS OF PLANTS IN LOWEST AND HIGHER AND CULTIVATED.

18. Ways of Living.

The contrasting modes of nutrition of the animal and the green plant, and of the relation of these to structure; the action of saprophytes in causing decay of organic matter, and the importance of this in soil formation and in the circulation of matter. Bacteria; nature and habits briefly; detection and culture. Uses of bacteria. Food Preservation. Pasteurisation. FLEA AND LOUSE AS ANIMAL PARASITES, AND THE MISTLETOE AND DODDER AS PLANT PARASITES; MALARIA AND AMEBELLAS; TAPEWORM; BREAD MOULDS AS PLANT SAPROPHYTES. DISEASES CAUSED BY BACTERIA AND IN PLANTS BY FUNGI; REFERENCE TO VIRUS DISEASES. CONTROL OF PESTS.

19. ECONOMIC USES of Animals and Plants.

Agriculture the fundamental industry. A brief account of the common cereals, pulses, fruits and vegetables as sources of food, and their relative importance. Cotton and wool as raw materials of clothing. MATERIALS OF ECONOMIC IMPORTANCE OBTAINED FROM PLANTS AND ANIMALS, IMPROVEMENT OF SEEDS AND STOCK, NATURAL AND ARTIFICIAL, PLANT PROPAGATION INCLUDING GRAFTING AND BUDDING, PRUNING.

20. Interdependence of Living Things.

Relation of the organism to its environment and to other organisms in nature; plant and animal communities; food chains; pollination, seed dispersal; sheep, rabbits, and plant growth. BIRD MIGRATION; PARTNERSHIPS COMMENSALISM; SYMBIOSIS AND PARASITISM.

21. Characteristics of Living Things.

Differences and resemblances between plants and animals. The idea of evolution. THE PROGRESSIVE NATURE OF EVOLUTION AS ILLUSTRATED BY REFERENCE TO THE SEQUENCE OF ANIMAL POSSIBILITIES.

SAMPLE II.

Syllabus prescribed by the Oxford and Cambridge Combined
School Examination Board in General Science (1955).

Ref. No. 124

GENERAL SCIENCE

The following papers will be set:

Physics	...	1½ hrs.
Chemistry	...	1½ hrs.
Biology	...	2 hrs.

PHYSICS

Fundamental properties of the three states of matter. Measure-
ment of volume by displacement. Density and its determination by
direct measurement of weight and volume. Specific gravity. Measure-
ment of density and specific gravity of a liquid. Fluid pressure.
Water-supply, hydraulic press, and other simple practical applica-
tions of fluid pressure. Principle of Archimedes; flotation, the
common hydrometer and other simple applications. The pressure of
the atmosphere. Simple aneroid barometers. Bicycle pump,
force pump, and lift pump. The spring balance and its use in the
measurement of force. Moments of forces and simple practical appli-
cations. Centre of gravity of a rod. Simple pulley systems, wheel,
and axle. Work. Mechanical advantage, velocity ratio and efficiency;
Principle of simple gears. Power, horsepower. Kinetic and poten-
tial energy treated qualitatively. Conservation of energy.
Mercury and alcohol thermometers. Centigrade and Fahrenheit scales.

Clinical thermometers. Qualitative treatment of the thermal expansion of solids, liquids, and gases; simple applications. Anomalous expansion of water. Measurement of heat generated by a source: calorie, B.Th.U., and there. Change of state. latent heats and their determination by boiling away water and melting ice. Cooling by evaporation and its practical applications. Dew-point and humidity; formation of mist, clouds. Conduction, convection, and radiation, and simple practical examples of the . Heat as a form of energy.

Rectilinear propagation of light, shadows, and eclipses. Reflection and refraction of light at plane surfaces. Converging and diverging lenses. Definition of focal length. Determination by graphical methods of the position and nature of images formed by converging lenses. The camera. The eye as an optical instrument; correction of long and short sight treated qualitatively. Magnifying glass. Dispersion of white light by a prism. Simple treatment of colour by addition and absorption.

Production of sound by vibration; material medium necessary for transmission. Relation between frequency, wave length, and velocity. Velocity of sound in air. Echoes. Pitch and loudness of a musical note. Measurement of frequency by simple methods. Resonance.

Simple phenomena of magnetism, the classification of magnets; theory of elementary magnets. The magnetic field. The magnetic effect of electric current.

Electrification by friction. Positive and negative charges. Conductors and insulators. Magnetics, thermal, and electrolytic effects of an electric current. Electrostatic, electrostatic, and electrostatic effects.

lighting circuit including lamps, fuses, and electric bells and buzzers. Electrolysis of dilute sulphuric acid with carbon electrodes and of copper sulphate solution with carbon electrodes. Electroplating. Simple cell, polarization, Daniell's cell, dry cell. Potential difference. Ohm's law. Resistance in series. The watt and kilowatt-hour. Moving coil galvanometer and its adaptation for use as an ammeter or a voltmeter. Electric domestic installation. The principle of the electric motor and the dynamo. The telephone receiver and transmitter.

CHEMISTRY.

Where the name of a substance is given without an indication of the limits of treatment, it should be understood that an elementary descriptive account of the substance and its properties is required.

(i) General Theory and Principles (to be illustrated by reference to the subject-matter of (ii)).

Matter: solids, liquids, gases. Fusion, sublimation, evaporation, boiling, distillation, diffusion of gases and solutions. Solution of solids, liquids, and gases in water. Suspension, precipitation, filtration. Crystallization from fused solids and from solutions.

Chemical Change. Catalysis.

Elements, compounds. Allotropy.

Atoms, molecules, symbols, formulae. Valency for use in simple formulae; calculation of percentage composition of compounds from formulae; equations.

Laws of Conservation of Mass and Constant Composition.

Oxidation and reduction (addition or subtraction of oxygen and hydrogen only).

Relative abundance of common elements (oxygen, silicon, aluminium, iron, calcium, sodium, potassium) in the earth's crust.

Electrolysis, ions.

Acids, alkalis, bases, salts. Preparation of salts by acid on base and acid on metal.

(ii) Air. Priestley's and Davy's discovery of oxygen. The laboratory preparation of oxygen and its manufacture from air without technical organisms and argon as constituents of air.

Hydrogen prepared from acids and water. Properties and uses of hydrogen. Hydrogen as a reducing agent for some of the metal oxides. Water as an oxide of hydrogen. Composition of water by weight.

Carbon: diamond, graphite, charcoal. Combustion of carbon. Carbon dioxide, calcium carbonate and bicarbonate, hardness of water. Elementary treatment of natural water, drinking-water. Reduction of carbon dioxide by carbon; carbon monoxide, its reducing power and poisonous nature. Properties of sodium carbonate and bicarbonate. Fuels: coal, coke, coal gas, producer gas and water gas, petrol, and oil. The Bunsen burner and the nature of flame. Smoke. The carbon cycle; wood and coal.

Nitric acid. Potassium, ammonium, and sodium nitrates.

Ammonia: its synthesis (conditions of reaction but not technical details) and catalytic oxidation. Reaction with acids, displacement from salts by bases. Laboratory preparation. Uses of chloride, sulphate, and nitrate. Nitrogenous fertilizers.

Sulphur: principal uses. Sulphur dioxide. Sulphuric acid; uses preparation by contact process, acid on a salt and dehydration agent. calcium and copper sulphates. Zinc sulphate (preparation only).

Sodium chloride. Hydrochloric acid, chlorine. Qualitative analysis of the occurrence, physical properties, reactions, composition of air, water, and dilute hydrochloric solution: magnesium, calcium, zinc, iron and steel, lead, copper, and mercury. The uses of these metals, including electroplating for copper.

Basic character and uses of sodium hydroxide, and its action on hydroxide.

Mortar and cement.

For the benefit of Schools where the topics taught as part of the General Science course, one or two additional months may be spent on the following:

An elementary treatment of the origin and use of igneous and sedimentary rocks. Weathering and erosion leading to soil formation. Folding and faulting.

BIOLOGY

Candidates will be expected to show knowledge of the main features of living organisms and their mode of life; it will be assumed that such studies have been based as far as possible on personal observation of actual living plants and animals both in the field and in the laboratory. Candidates will be expected to be able to perform simple experiments, to draw conclusions therefrom and to understand the necessity for control experiments. Questions may be asked which are designed to test the powers of observation and reasoning of the candidates. They may be asked to make practical observations of actual animals or plants and to describe specimens which they may not have seen before. Although no direct question will be ~~put~~ on evolution,

candidates will be expected to understand the conception of the evolution of organisms.

It will be expected that organisms will have been studied by means of a hand lens or, where necessary, a microprojector or a compound microscope.

The characters of living organisms; differences between higher animals, micro-organisms and higher plants as illustrated by a mammal and especially man, yeast and bacteria, and a flowering plant respectively.

Protoplasm, nucleus, and cytoplasm illustrated by amoeba and plant cells. Elementary facts about the composition of protoplasm, proteins, carbohydrates, fats, salts. Cell multiplication. Growth.

Conditions necessary for life. Sterilization by chemical action. Effect of temperature on the activity of yeast. Biological effects of high and low temperatures including their application in refrigeration and sterilization by high temperatures.

Nutrition. The three main types exemplified by a flowering plant, *Mucor* and man. The constituents of an adequate human diet. The interdependence of the nutrition of all organisms illustrated by food chains, the carbon and nitrogen cycles in nature (without names of specific bacteria). The part played by enzymes in digestion and synthesis.

Respiration. Essentials of respiration in flowering plant and mammal.

Movement. Locomotion of animals, and tropisms of plants. The

skeleton of a mammal in general outline. Simple examples of muscle action including illustration of leverage.

Nervous co-ordination. An elementary account of the sense organs. Initiation of action by the sense organs and nervous system. Elementary account of the reflex arc.

Reproduction. Asexual (Amoeba, planor), vegetative (potato), and sexual methods (flowering plant and vertebrate). The significance of the different methods. Reproduction of frog and mammal to show essentials of fertilization and parental care.

SAMPLE III.

Syllabus in General Science for the first three years of the Senior Secondary Schools of Scotland (12+ to 15+) prescribed by the Scottish Education Committee for the Scottish School Leaving Certificate Examination (1957). Specialisation will commence in the fourth year.

Rt. Page 24

SCIENCE - FIRST YEAR

The Bunsen burner. The three states of matter. Change of state.

Operations

Solution, filtration, evaporation, crystallisation, distillation, sublimation, separation of mixtures.

Weight & Density

Use of spring, Butchart and Bean balances. Determination of the density of solids and liquids, making use of the measuring jar, burette and pipette.

Heat

Expansion of solids, liquids and gases.

Thermometry

Experiments to distinguish between heat and temperature. Graduation of a thermometer. Types of thermometers - clinical, maximum and minimum.

Chemistry

The fuming of phosphorus and the rusting of iron. The composition of the air.

Magnetism

Experiments to show the magnetic properties of magnets. Making of magnets. Methods of de-magnetising and preserving magnets. Magnetic induction.

Chemistry

Physical and chemical changes. Elements, mixtures and compounds. Distinctions between a mixture of iron and sulphur. Atoms and molecules. Surface Tension.

Simple experiments to illustrate surface tension.

Biology

Signs of Spring. Development of the trout observed in school. Characteristics of winter twigs. Structure and germination of seeds. The parts of a flowering plant, including the study of flowers. The earthworm and its importance in agriculture. The housefly and the butterfly.

NOTE: Biology begins in February and is taken on alternate days with physics or chemistry.

SCIENCE - SECOND YEAR.

Biology

Signs of approach of winter. Revision of flower parts and pollination. Fertilisation. Dispersal of Fruits and seeds. Structure and life history of a bird. Planting of Bulbs and Corms.

Pressure

Distinction between pressure and thrust. Experiments on air pressure using an air pump.

Light

Rectilinear propagation of light. Shadows. The pin-hole camera. Simple direct beam experiments to show reflection of light from surfaces (Plane).

Oxygen

Heating of Mercury oxide. Heating of potassium chlorate and manganese dioxide. Formation of oxides, acids and hydroxides.

Acids, Alkalis and Salts

Characteristics of common laboratory acids. Distinguishing tests for acids - (a) action on indicator; (b) liberation of carbon dioxide from solid carbonates; (c) reaction of alkali with formation of salt. Preparation of salts by neutralisation of an alkali by an acid. The action of metals on water, steam and dilute acids.

Hydrogen

Preparation, properties and uses. Coal gas. Copper sulphate test for water.

Electricity

Wiring of a simple circuit. The electroc net and electric bell. Conductors, resistors and insulators. Heating effect of a current. Purpose of a fuse.

Liquid Pressure

Experiment to show pressure at right angles to the surface. Experiment to show pressure depends on depth.

Barometers

The mercury barometer. The aneroid barometer and its use.

Transmission of heat by conduction, convection and radiation.

Carbon dioxide

Preparation, properties, composition and uses. The carbon cycle in nature.

The Lever.

Law of the lever. Mechanical advantage. Principal of movements.

Biology

The development of frog spawn. Structure and life history of

Amoeba. Structure of a plant cell. Difference between plant cell and animal cell. Examination of blood; structure and functions of blood. Blood vessels. Circulation of blood in a fish - the heart and circulation. Blood temperature - cold and warm blooded animals.

Food

Carbohydrates, fats and proteins. Curves and simple tests. Use of mineral salts and vitamins. Balanced diet. Digestion in man. Experiments on Digestion using (a) Starch, (b) boiled White of Egg. The alimentary canal of man. Harmful bacteria, sterilisation, vaccination and inoculation. Photosynthesis and respiration in plants.

NOTE: Biology in Spring Term begins in February and is taken on alternate days with physics and chemistry.

SCIENCE - THIRD YEAR

Light

Refraction of light. Effect of converging and diverging lenses on parallel beams. The magnifying glass and the eye.

Archimedes Principle

Experimental verification. Application to finding the specific gravity of a solid and a liquid. Experimental verification of the Law of Flotation. The Plimsoll line; submarine and floating dock. The direct reading hydrometer.

Radiation

Emission and absorption. (Revision) The electric radiator, conservatory and thermos flask.

Heat

Revision of effects of heat. Anomalous expansion of water.

Measurement of Heat

Units - thermal capacity and water equivalent of a vessel. Specific heat by the method of mixtures. Latent Heat of Steam and Latent Heat of Fusion of Ice by the method of mixtures. Experiment to show water expands on freezing and ice contracts on melting.

Melting point.

Determination for naphthalene by cooling curve method.

Electricity

Conversion of chemical to electrical energy. The simple voltaic cell; Daniell cell; dry cell and accumulator. Ohm's law. Simple calculations. Cells and resistances in series and in parallel.

Magnetism

Plotting of simple magnetic fields. Magnetic effect of an electric current. The electric motor and dynamo.

Sound

The production and transmission of sound. Velocity in air. Intensity, pitch, quality. Reflection of sound.

Chemistry

Action of heat and acid on calcium carbonate. Determination of percentage weight of carbon dioxide from chalk. Preparation of calcium bicarbonate solution. Preparation of temporary and permanent hard water. Determination of degree of hardness using soap solution. Methods of softening hard water.

Boiling point

Differences between boiling and evaporation. Effect of rapid evaporation of a liquid. Effect of dissolved substances on the boiling point of water. Effect of pressure on the boiling point of water. Vapour pressure. Boiling point of a liquid by vapour pressure method.

Melting Point

Effect of increase of pressure on the melting point of ice; regelation. Effect of dissolved substances on the melting point of ice. Freezing mixtures.

Biology

Parts of a root. Functions of roots. Gaseous absorption of soil water by roots. Simple osmotic and transpiration. Localization in mammals. The importance of water in plant and animal life. The main bones and joints of a mammal - movement, position, appearance and functions of the main organs in a mammal. Brief outline of nervous system in a mammal. Characteristics of living things. Structure of the eye and ear.

NOTE: Biology begins in February and is taken on alternate days with physics or chemistry.

SAMPLE IV.

A Teacher's working Syllabus in General Sciences for the
English Modern School. Theory and Practical - I
Four Year Course.

Ref. Page 104, 217, 227

The general aims of the scheme are

1. to introduce the pupils to the 'scientific method' of approaching a problem (observation, recording, interpretation experiment and application)
2. to foster a healthy curiosity concerning the how, why and where of everyday happenings.

These ends are approached by (a) individual practical experiments and (b) class lessons on fundamental scientific principles and their application.

The experiments are detailed on work cards and so arranged that about thirty different experiments may be made by each child, working individually, during each school year. During the fourth year pupils are encouraged to follow any personal enthusiasm or investigate any problems relevant to their proposed occupations which may arise.

(Although it is recognised that by the adoption of this method a pupil's work may lack continuity it is felt that this disadvantage is far outweighed by the facts that

- (a) working alone is an adventure which calls for self-reliance and personal effort
- (b) since only set off apparatus of each kind is needed it can be designed and made to suit the particular problem
- (c) the need for storage is reduced to a minimum).

The class lessons - short lecture demonstrations in form - are intended to weld the practical work to other and link it up with the processes and practices which the pupils observe from day to day. Question time and reports from students or groups are part of the scheme as well as 'out of school' collection of specimens, pictures or information. When possible, field work in biology will be undertaken and collection and identification of specimens by individuals will be encouraged, model specimens being exhibited in season. The first and second year pupils will be concerned with 'what' is to be done, the third will consider 'where' and 'why' and the fourth will attempt some simple study in ecology. In all cases the importance of recording place, time and conditions will be emphasised.

With the use of Humphrey Ford Camp available to the third year an attempt will be made to prepare (by consideration of the flora and fauna of such an area) for the investigation of some particular problem during the stay.

Although the main scheme is the same for all classes in the same age group full allowance will be made in the presentation and examination of the work for the inherent differences between the 'A', 'B' and 'C' groups. The account of an experiment required may vary, according to the capacity of the scholar, from a complete written statement with argument, conclusion and application, to an annotated diagram and oral answers to questions. The importance of diagrams and tabular forms will be stressed with all pupils.

On suitable occasions use will be made of the Film-strip

projector and biological specimens examined by microscope and micro-projector.

Class Lessons

- Form 1. Air, burning, rusting and tarnishing, Use of clear varnish. Units of measurement (including metric system). Need for standards (collection of examples) Thermometers - kinds and uses. Solar system - seasons, day and night, gravity. Time - clocks. Bicycle - leverage, the wheel, friction, gyroscope. Musical instruments - sound in general. Structure of plant - life cycles. Parts of flower, examination of typical examples. Investigation of a pond or stream. Human physiology - simple account of the organs of the body and their functions linked with simple First Aid. Lives of selected scientists (e.g. Priestley, Pasteur)
- Form 2. Heating systems. Law of conservation of energy. Basis of chemistry. Law of conservation of matter. Atoms, molecules, mixtures and compounds, acids and Alkalis. Photography. Accurate measuring - vernier, screw, optical lever, etc. Solvents in industry. Varnishes, dry cleaning etc. Dangers. Structures and strength - bridges (collection) Colour - the spectrum, rainbow. Tricks with coloured light. Digestion - function of glands and organs. Absorption of food and elimination of waste. Investigation of pond or stream life - identification of some natural orders.
- Form 3. Temperatures - for cooking etc. Change of state. The eye and spectacles. Colour and flurescent dyes - modern detergents. Electrical installations - dangers and precautions. The barometer - mercury and aneroid - altitude, weather, air pressure in use. Water proofing and wetting agents. germs and disinfectants. Work of Pasteur and Lister.

Growing worms and killing them (e. .bottling fruit)
Respiration in different orders of life.

Blood circulation - blood transfusion - First Aid.
Reproduction.

Use of 'keys' in reference books. Collection of specimens
from field and stream.

Form 4. Pressure cookers, electric irons, gas ovens etc. in the
home. Automatic electric devices. Dynamo and electric
motor. Practical photography - optical instruments.
Textile fibres - recognition and treatment. Processes.
The steam engine. Internal combustion engines old and new.
Fitness for purpose of materials e.g. in building.
Cleaning agents - solvents, detergents, bleaches etc.
Tempering steel. Study of some fundamental properties
such as elasticity, hardness, toughness.
Introduction to ecology - life cycles, nitrogen cycle,
carbon dioxide cycle, plant and animal communities.

Where possible these lessons will be supplemented by visits
to factories to see the practical applications.

List of Experiments

Forms 1 and 2

1. Conduction
2. Insulation
3. Convection
4. Thermometers
5. Expansion
6. Thermometer scales
7. Magnets 1
8. Magnets 2
9. Magnets 3
10. Magnetic field
11. Reflection in plane mirror
12. The curved mirror
13. Refraction
14. Pendulums 1
15. Pendulums 2
16. Measurement of length 1
17. Measurement of length 2

18. The screw micrometer
19. Area 1
20. Area 2
21. P₁ by weight
22. Volume of solids (rectangular)
23. Volume of liquids
24. Volume and weight of water
25. Volume by displacement
26. Centre of gravity
27. Equilibrium
28. Hills
29. Elasticity of air
30. Density
31. Induced lines of force
32. Construction of 'mariners' compass
33. Simple pulleys
34. The spring balance
35. Levers 1
36. Levers 2
37. The steelyard
38. The chemical balance
39. Weighing with an accurate balance
40. Filtration
41. Solution and crystals
42. The bunsen burner
43. The bell-jar experiment
44. Making oxygen
45. Distillation
46. Acids and alkalis
47. Solvents (alcohol and turpentine)
48. Carbon dioxide
49. The waste tap
50. The trap and syphon
51. Model 'flush box'
52. Ties and struts (parallelogram of forces)
53. Sound in vacuum
54. Monochord
55. Resonance
56. Shadow box (square law)
57. Pulse
58. Lung capacity
59. Flower structure
60. Identification of starch.

List of experiments

Forms 2 and 4

1. Melting points - wax and solders
2. Frying and boiling
3. Lenses - raybox
4. Quantity - separating mixtures
5. The spectrum
6. Coloured light
7. Construction of telescope (astronomical)
8. Construction of telescope (Galileo's)
9. Archimedes' cylinder
10. Specific Gravity by immersion
11. Buoyancy - the diver
12. The hydrometer - uses
13. Blocks and tackle - pulley systems
14. Inclined plane and screw
15. Pitch and profile of threads
16. Friction
17. Viscosity
18. Automatic syphon
19. Villa e pump - valves
20. Soap films - surface tension
21. Gears and mechanical advantage
22. Conduction and insulation of electricity
23. Voltage, current and resistance
24. Sources of electricity
25. Resistances
26. Switches
27. Heating effects - fuses
28. The D.C. Motor. Model
29. Electric Magnet and bells
30. Lamps and wattage
31. Neutralisation - acids and alkalis
32. Acid on carbonate fire extinguisher
33. Solvents
34. Wetting agents
35. Emulsification
36. Hard water - tests and prevention
37. Etching with acids
38. Mirrors at an angle (Kaleidoscope, tricks)
39. Lubrication - wheel and axle
40. Brakes - weight and area.

The construction of scientific models and individual investigation will be encouraged. Experimental procedure will be checked or suggested where necessary.

SANILE V

A Four Year Course of General Science prescribed for the
Higher Secondary Schools of Mysore State.

Ref. Page 214, 223, 224

GENERAL SCIENCE.

Class VIII.

(3 hours per week divided into 4 periods of
45 minutes each).

Unit I. Life Studies:

(A) Plant Life:

- (i) Plants - Types: Herbs, Shrubs and Trees with examples.
Annuals, Biennials and Perennials
- (ii) Uses of Plants as sources of food, shelter, clothing,
medicines, etc.
- (iii) Different kinds of common crops and regions and seasons
favouring the growth of such plants.
- (iv) Transpiration and Conservation of Soil water.
- (v) Pulses as fixers of Nitrogen, Crop Rotation.
- (vi) Economic Plants: Coffee, Tea, Tobacco, Arca Nut, Coconut,
Sugarcane and Chillies.
- (vii) Medicinal Plants.
- (viii) Flowering Plants - Seasonal Flowering
- (ix) Timber Trees useful for carving, furniture and building works
- (x) Earthwork as a friend of the Farmer
- (xi) The parts of a typical flowering plant and a simple account
of their functions; Root, Stem, Leaf, Flower, Fruit and Seed.
- (xii) Flower and its parts
- (xiii) Pollination: Self and Cross Pollination.
- (xiv) Fruit and Seed Dispersal.

(B) Animal Life:

- (i) Animals - Classification as Vertebrates and Invertebrates with a few examples of each.
- (ii) Food habits and Structural adaptations of Herbivores, Carnivores, Rodents - two animals of each type.
- (iii) Usefulness of animals (including insects and birds), as sources of food, clothing - Draught animals and pets.
- (iv) Sources of Wool, Skin, Hide and Feather.
- (v) Harmful Animals including insects and birds, and spread of diseases through them.
- (vi) Feet and Beak of birds with reference to their food habits.
- (vii) Animal migration - Bird banding protection of wild animals - sanctuaries - their purposes and location.
- (viii) Warm and Cold-blooded animals.
- (ix) Coverings of Animals.
- (x) Need for storage of food in plants - Storage organs in plants.
- (xi) Vegetative propagation in plants - raising of plants from leaf, root, cuttings and by layering.
- (xii) Living and Non-living things - distinguishing features of each kind.
- (xiii) Differences between plants and animals.

Unit II. The Universe around us:

- (i) The Sun - its size, distance from Earth, nature, sun spots, sun as a star and seasons.
- (ii) The Moon - its size, distance from Earth, nature, phases and tides.
- (iii) Solar and Lunar systems of Calendar.
- (iv) Solar and Lunar Eclipses.

Unit III. Nature of things:

- (i) Units of measurement- simple laws of the Pendulum.
Use of Balance - Density of objects.

- (ii) Air - The atmosphere around us. Air has weight. Air exerts pressure. Barometer, syringe and common pump.
Composition of air - increase in weight during burning -
Use of Oxygen in combustion - presence of oxygen and nitrogen in air.
Rusting, prevention of rusting, use of paints.
Active and slow combustion - Combustion in animal body.
Carbon-di-oxide in air - how added and removed.
Contamination of air by industrial process, by respiration, breathing and burning.
Water vapour in air - Evaporation - conditions favouring evaporation.
Condensation of water vapour in air - Mist, fog, dew, rain, snow and hail.
- (iii) Water - natural sources - rain - river - spring - well - tank and seal.
Impurities in drinking water - Purification - decantation - filtration - distillation.
Rural and Urban water supply.
Properties of liquids - Pressure at a point - upward, downward, sideward. Liquids find their levels. Transmissibility of pressure - Bramah Press.
Solution - Saturated, unsaturated, solubility, Crystallisation
Mixtures - Properties of mixture - methods of separation, simple Physical processes - decantation, filtration, evaporation, solution, distillation, etc.
Physical and Chemical changes - Four types of simple chemical changes.
Elements and Compounds.
Action of water on metals - Sodium, Magnesium and Iron.
Hydrogen - its preparation and properties and uses.
Composition of water by volume.
Oxygen - preparation, properties and uses.
- (iv) Infection.
Ways by which Bacteria get into human body - through food drinks, air wounds, insect and animal bites.
Disinfectants - Lime, bleaching powder, boric acid, carbolic acid, chlorine, hydrogen peroxide, iodine, potassium permanganate, D.T., etc - and how they are used.

Unit IV. Energy and Work.

Heat - Sources of Heat - Sun, fuel, oil, coal, electricity, friction.

Effects of heat - Expansion effects on solids, liquids, and gases and their practical applications.

Thermomets - Fixed points of a thermometer - the two scales - Fahrenheit and Centigrade Scales.

Clinical Thermometer.

CLASS-IX.

(8 periods a week)

Unit I - Life.

(a) Human body - Primary divisions of the body organs.
Digestive System - (i) Need for food - body builders and heat producers - Different types of diets - need for balanced diet.

(ii) Digestive organs - Process of digestion and assimilation.

Circulatory System - (i) Heart and blood vessels, (ii) Functions of heart, blood vessels and blood, (iii) The blood contents, (iv) Care of heart - pulse.

Respiratory System - (i) Organs of respiration and process of respiration, (ii) Nature of inspired and expired air - ventilation, (iii) Correct mode of breathing - posture, (iv) Care of respiratory system

(b) Growth - (i) Part of a bean and maize, (ii) Different stages of germination- Conditions of germination.

Unit II - Universe around us.

Solar System - (1) Planets, comets and meteors

(2) Earth - Its crust, Elevation - Hills and mountains depressions, lakes and seas.

(3) Rocks - Igneous, metamorphic and sedimentary layers and their ages, fossils and their significance in tracing evolution.

(4) Work of running water - Valleys, Gorges, erosion, conservation of surface soil - afforestation, action of air, water, sun's heat (weathering of rocks) (formation of soil).

Soil - Composition of soils (mineral and organic matter, their function) Types of soil.

Unit III - Nature of things.

Non-Metals

- (a) Nitrogen and Ammonia - Natural and artificial sources, care in the use of artificial fertilisers.
Nitric acid - Preparation, properties and uses.
Carbon - Allotropic forms of carbon.
Carbondioxide - Preparations, properties and uses.
Sulphur - Allotropic forms - properties and uses.
Sulphuric acid - Properties and uses.
Chlorine - Preparation, properties and uses.
Hydrochloric acid - Preparation, properties and uses.

Unit IV - Energy and Work.

(a) Heat - Transmissions of heat - conduction, convection and radiation.

Common applications - Thermos flask.

Domestic heating and air conditioning

(b) Light - Luminous and non-luminous bodies.

Velocity and speed of light - Light year Reflection - laws of reflection.

Plane mirrors - Images in plane mirrors.

Concave and convex mirrors - Nature of images, use of the mirrors.

Refraction - Path of a ray through a slab, a prism and water (qualitative only)

Dispersion of light - formation of a rainbow.

CLASS X

(3 periods a week)

Unit I - Life.

(a) Nutrition in plants - Photosynthesis - simple experiments to demonstrate starch formation in a green leaf and liberation of oxygen - Result of overcrowding in gardens and fields.

Nutrition in non-green plants.

Just a mention of plant parasites and common insectivorous plants.

(b) The external, habits and life history of butterfly, silkworm and silk industry.

The external, habits and life history of a frog.

(c) Excretory organs - A brief account of the work of skin, lungs and kidneys. Hygiene of hair, nail and skin. proper clothing.

Skin and line diseases.

(d) Nervous system - Different parts of the nervous system - Brain, its parts and functions - Spinal chord - Nature of reflex action - Reflexes.

Sense organs - and skin care.

Unit II. Universe around us.

Our galaxy - Path of the sun and the moon in the Zodiac, star constellation - Indian constellation of 27 stars.

Stars - Distance, size, weight and magnitudes of stars - nebulae in our galaxy.

Unit III. Nature of things.

(a) Buoyancy - Principle of Archimedes, relative density, floating bodies, hydrometer, lactometer.

(b) Lenses and their uses (Qualitative only) Camera, microscope (simple and compound), astronomical telescope, and magic lantern.

(c) Non-metals - Phosphorus - allotropic modifications - properties and uses - Phosphates as manures.

(d) Metals in common use - (Properties and uses), Iron, copper, aluminium, tin, mercury, silver and gold - common alloys (Brass, bronze and solder and stainless steel).

Extraction of Iron - Forms of iron

Extraction of aluminium (Electrolytic method) - (only these two metals)

(e) Common things we use - Paper, Matches, Inks, Soap, Glass, Cement (how they are made).

Unit IV - Energy and Work.

(a) Magnetism - different kinds of magnet - bar, needle horse-shoe.

Properties of magnets -

Earth a magnet - Mariners compass.

Electricity - Cells and ways of overcoming polarisation - Daniel, Leclanche (dry and wet), bichromate cells.

Circuits - Switches.

Effects of Electric Current - J. Martin and Lighting, fuses, electric heaters, lights.

Magnetic effect - Galvanoscope.

Electromagnet - Electric Bell, Principle of telegraphy.

Chemical Effect - Electrolysis - Electroplating.

CLASS XI

(3 periods)

UNIT I. - Life.

(a) The Cells - Structure and division, plant cells and animal cells - Elodea and Funaria

(b) Bacteria - useful - Fermentation, soil bacteria, nodule bacteria, nitrogen-fixing bacteria.

Harmful bacteria - disease causing.

1. Through food - Cholera, typhoid.

2. Respiratory - Consumption and Inebriety

3. bites of animals and insects - malaria, plague

Methods of overcoming bacterial diseases.

1. Natural immunity.

2. Killing bacteria by drugs - quinine and penicillin.

3. Immunisation by inoculation and vaccination - Cholera, Plague and Small-Pox.

4. Antitoxin method - Rabid dog - Snake poison.

Refer to the work of Jenner, Pasteur, Lister and Fleming.

(c) Interdependence of Plant and Animal Life - Mention of Carbon and Nitrogen cycles in nature.

Human body as a machine.

Endocrine glands and hormones, diseases, caused by defective functioning of these glands.

Vitamins - Foods rich in vitamins. Vitamin deficiency diseases.

(d) First aid. -

Fractures - Simple and compound - which the pupil should attend to and which he should not. Cut and bruises.

Bleeding - Prevention - ligatures.
(Refer briefly to antiseptics).
Burns and scalds.
Insect bites and snake bites.
Respiratory - asphyxia, drowning - first aid in those cases.
Fainting bodies - in the eye, nose and ear.
Street accidents, Foundry and shocks. Poisons.

(c) Organic Evolutions - A very elementary idea of the Doctrine of Descent and Darwin's contribution.

Unit II. Universe around us.

Gravitation - The movement of planets and their satellites.
Galaxies - Vastness of the Universe - Milky way.

Unit III. Nature of things.

(a) Acids and alkalis - Their properties, their neutralisation and formation of salts - source of common salt.

(b) Hard and soft waters and methods of softening hard water.

(c) Persistence of vision and motion pictures.

(d) Sound - How produced and how transmitted. Sound vibration - stringed musical instruments, reflection of sound - formation of echoes - Gramophone.

(e) Electricity - magnetic field, lines of force, induced currents - dynamos AC and DC
Carbon microphone - Telephone.
Electric Motor - uses and advantages.
Radio and Broadcasting.

(f) Work and Simple machines.
Elementary knowledge of speed, velocity, acceleration and inertia.
Inclined plane, wheel and axle.
Pulleys.
Power transmission by gears, chains and belts.
Simple levers.
Windmill, water wheel, and turbines.
Steam Engine and Oil Engines, Aeroplane.

(g) Simple ideas of Atomic Energy - Elementary ideas of the structure of the atom.

SAMPLE VI

An Activity Syllabus developed for a six year Elementary School in America. Each activity is to form a problem for children to solve.

Ref. Page- 226

Autumn Science Activities for the Elementary School.

Exploring the School ground
Establishing a Nature Trail
Exhibiting Summer Projects at the School Fair.
Keeping a Nature Calendar
Keeping a Diary of Fall Visits to a Favorite Tree
Rearing Insect Larvae
Arranging an Insect Orchestra
Preparing an Exhibit Showing Damage and Benefit from Insects
Keeping a Gallery of Bird Residents and Travelers
Making Friends with the Birds
Finding What Foods the Birds Like Best
Learning to Know the Common Trees and Their Uses.
Learning to Know the Fall Wild Flowers
Holding a Harvest Festival
Finding by Experiment and Observation What Becomes of the Seeds
Saving Seeds for Planting.
Finding How We Get our Foods
Finding How We Get Our Clothing.
Holding a Fall Flower Show
Taming Animals and Learning Their Ways
Discovering and Studying Animal ~~xxxxxx~~ Homes
Watching Animals Feed.
Preserving the Beauties of Autumn.
Cooking a Meal Out of Doors
Discovering What People Are Doing to Prepare for Winter
Discovering What Animals Do as Winter Approaches.
Collecting Insect Pupae.
Stocking the Aquariums.
Setting up Terrariums.

Examining the Plants as Winter Approaches
Starting the Bulbs for a Winter Flower Garden
Making a Collection of Stones Which Tell a Story of the Past
Starting a School Museum.

Winter Science Activities for the Elementary School.

Keeping a Winter Nature Calendar.
Making Scrapbooks of Winter Scenes and Sports
Watching the Changing Day
Learning to Tell Direction.
Learning to Guess Time by the Sun
Making Evening Sky Maps
Demonstrating Night and Day and the Changing Seasons
Tracing Our Relations with the Rest of the World
Making a Study of a Snowfall
Finding the Street Fixtures and Learning Their Uses
Learning to Guess Temperature
Finding and Making Objects That float
Changing Things into Other Forms
Setting Up a Simple Weather Station.
Making Toy Wind, Water, and Steam Power Generators
Finding out What Things Are Made
Collecting Common Metals and Studying Their Uses
Wiring Simple Electric Circuits
Experimenting with the Powers of Magnet and Compass
Making an Electromagnet
Discovering How Our Electric Devices Work
Holding Glider and Airplane Races
Tracing the Activities of Animals by Their Tracks in the
Snow
Befriending the Winter Birds
Comparing the Christmas Trees
Holding a Winter Flower Show
Growing a Winter Garden of Twigs
Comparing Our Dogs
Listing Our Friends and Foes
Comparing Our Range of Foods
Comparing Ourselves with Other Animals
Showing How Our Toys work
Finding the Uses that We Make of Science
Holding Open House at the Museum.

Spring Science Activities for the Elementary School.

Discovering Where Ice and Snow Linger Longest
Discovering Signs of Spring
Keeping a Spring Weather Calendar
Setting Up a Homecoming's Gallery
Observing and Reporting New Life
Growing Tiny Plants and Animals
Making a Wild-flower Gallery
Exploring by Sound and Touch
Observing the Happenings on Windy Days
Observing the Effects of an April Shower
Making Maple Sugar
Making Whistles
Keeping a Spring Diary of a Tree
Discovering Which Trees Waken First
Running a Plant-growing Race
Starting Trees from Seeds
Planting a Tree
Starting Plants for Our Home Gardens
Running an Insect Hatchery
Investigating Ant and Honeybee Colonies
Rearing some Toads to Protect Our Gardens
Caring for Our Pets
Helping Mother Hen Rear a Family of Chicks
Stalling Birds to Learn Their Ways
Keeping a Diary of a Bird Family
Starting a Bird Haven
Protecting a Wild-flower Nook
Making a Wild-flower Survey
Watching Flowers Form Fruits
Gardening the Play house
Exploring a Brook or Pond
Tracing the Story of a Stream Valley
Making a Study of the Principles Employed in a Local
Industry
Holding a Science Exhibit.

SAMPLE XII

(Appendix II)

Syllabus in General Science for the Seven Year Primary School
prescribed in Mysore State. Each topic is correlated with
some activity.

Ref. Page 210, 224

I. Objectives of teaching General Science are:-

- i. To keep the children in touch with their environment so that they develop love of nature.
- ii. To help them to understand plants, animals, and natural phenomena in their environment and to make them understand themselves as living organisms.
- iii. To train in accurate observation.
- iv. To make use of health services available and to make them understand some of the factors that influence individual and community health, and
- v. To help them to draw correct inferences.

II. Suggestions for teachers:-

- i. The study of General Science should, as far as possible, be related to the activities and the interests of the children.
- ii. The subject should be taught by actual observation, personal experience, and simple experiments.
- iii. It is expected that good use will be made of the schoolgarden, surrounding fields, farms museums, zoo's and such other places for visits and excursions.
- iv. Correlation with as many subjects as possible must be adopted in all grades and at all stages.

v. The activities given in the syllabus are merely suggestive and not exhaustive. Teachers are at liberty to modify, and add to them to suit local conditions.

vi. Many of the experiments suggested for Standards V to VII may be carried on with locally improvised materials and appliances. Therefore the teachers should not depend much upon the apparatus and materials to be supplied by the Department.

Topics for Study.

Activities

STANDARD 7 YEAR

I. How to live well

Personal hygiene - daily cleaning of face, eyes, nose, teeth and nails.

Daily bath, cleaning and washing hands, feet, mouth before after taking food.

Wearing clean clothes, dressing hair, building up good habits relative to the above.

i. Daily health inspection of pupils by pupils

ii. To attend to the personal hygiene of the pupils:
Cutting the nails
cleaning the teeth
cleaning the nose
cleaning the eyes
Combing the hair.

iii. To collect health posters and exhibit them in the school.

II. Food.

Ragi, rice, jole and wheat - staple food according to locality. Their Uses and recognition.

Milk, Egg, and Leafy vegetables - their importance.

i. Visit to dry and wet fields, poultry and dairy farms in the neighbourhood.

ii. To collect grains of as many varieties as possible.

III. The world around us:

Domestic animals - Cow, Buffalo, Sheep, Goat and ~~Mongoose~~ - Dog, their external features, food and movement. Useful birds - Fowl and Crow - their food, cry and flight - external feature.

Sky - Sun.

Sunrise - east sunset - West. Light and heat from the Sun.

i. Visit to Zoo, cattle sheds, etc.

ii. To observe Sunrise and Sunset.

STANDARD II YEAR

I. How to live well:

To answer calls of nature - proper time, place proper use of water, for cleaning.

To build up healthy habits of answering calls of nature.

How to take food and drink water in a clean and systematic way.

- i. To use the urinal of the school properly.
- ii. To clean the class-room, to dispose off the waste.
- iii. To keep things tidy.
- iv. To keep surroundings clean
- v. To arrange for drinking water in school.

II. Food.

Pulses-avarai, thogari, hurali, kadale, etc., their recognition and uses; Recognition of their plants.

Fruits- Plantain, Papaya or any two of the locality.

- i. To visit fields where pulses are grown.
- ii. To collect pulses.
- iii. To collect seeds of various fruits.
- iv. To prepare clay models of fruits.

III. The world around us.

Animals - cat, rat, horses, donkey - Their external features, food and movement.
Birds - Sparrow, dove, parrot, Their food, cry, flight and external features.

Sky - Moon, - Night and day.

Dark and bright fortnights.

Four directioners - North, South, East, West.

- i. To imitate cries of birds and animal.
- ii. To mark north, south, east and west in the school.
- iii. To observe the various phases of the moon.

STANDARD III YEAR

How to live well:

How to breath - fresh air.

How to clean the clothes with soap. Posture - right position for:

- i. Sitting
- ii. Standing
- iii. Walking
- iv. Sleeping.

- i. Cleaning in and around the School.
- ii. To develop the habits of correct postures in the various activities.

Food:

Studying the facts about the plants already observed.
Naming the parts - roots, stem, branch, leaf, flower and fruit and seed.
Vegetables - any four of the locality may be studied.

- i. To collect flowers of the locality and name their parts.
- ii. To prepare pits and beds for school garden by digging, manuring, sowing, watering and weeding.

The World around us:

Animals of the pond or river frog, fish, duck - their external features, food and movements.
Insects - Butterfly, grasshopper, earthworm, white-ants and ants - Their external features - Their movements.
Sky - clouds, rains, rainbow. Rainy season and other seasons.
Soil - different kinds - different plants grow in different soils.

- i. To visit a pond or river and observe the animals.
- ii. To observe the white ants and earth worms at work.
- iii. To collect butterflies and grasshoppers.
- iv. To observe clouds and rainbow in the sky.
- v. To collect various samples of soils.
- vi. To record the number of days of rainfall in every month of the year.

STANDARD IV YEAR

I. How to Live well:

Need of manual labour, proper rest and sleep. Good food, exercise, fresh air, enrich the blood.
Clothing - different kinds - Cotton, silk, wool.
Change according to season.
Effects of tobacco, alcohol, Coffee and tea.
Common communicable diseases - Malaria, Plague, Cholera, Small Pox. How to avoid infection. Mosquito and housefly as carriers of infection.
First aid - sore eyes - cuts, burns, fire accidents.

- xi. To join in Social Service work
- ii. To visit the breeding places of mosquito and housefly.
- iii. To observe D.D.T. spraying.
- iv. To help fill the compost pit.
- v. To construct soak pits, latrines and urinals.
- vi. To practise the safe use of the roads.

II. Food.

Some articles of food that can be consumed raw coconut, cucumber, tomato, lime. Meat as food - fish as food. Balanced diet and its food factors.

- i. To run a kitchen garden.

III. The World around us:

- | | |
|---|---|
| Wild animals - any four e.g., panther, wolf, wild pig, fox, elephant, etc. - useful and harmful to man. Insects - Bee and silk worm-their life history. Spider, lizard, scorpion, cockroach, bed bug - their external features. | i. To collect pictures of animals, birds and insects. |
| Plants - Study of Dasevala, Battura or any other big flower of the locality. | ii. To visit a zoo. |
| Study of a fruit tree of the locality; Mango, tamarind, etc. | iii. To observe a spider building its web. |
| Sky - Star and planets, Moon stars and Great Bear. | iv. To observe a lizard catching an insect. |
| | v. To observe insects that visit flowers. |
| | vi. To start a school museum. |
| | vii. To observe Venus and Mars when possible. |
| | viii. To observe the Great Bear. The Pole Star - The milky way and the Orion. |

STANDARD V TO VII YEAR

The following general activities are suggested for all the three standards:

- i. To run a kitchen garden.
- ii. To construct and maintain soak pit, compost pit, urinal and latrine.
- iii. To construct and maintain a proper fencing for the school.
- iv. To take part in community health activities.

STANDARD V YEAR

I. Air

- | | |
|---|--|
| Air necessary for ~~breathing~~ and burning | i. Experiment - a burning candle is put out when covered with a tumbler. |
| Respiration in man and respiratory System. | ii. Demonstration with the help of a chart |
| Respiration in fish | iii. Demonstration of gills in a fish. |
| Respiration in plants. | iv. Experiment of germinating seeds. |
| Difference between air taken in and air breathed out. | v. Expt. Blow through lime water and observe the change. |
| Impurities in air - Dust, carbon-di-oxide, and germs. | |

II. Water.

Sources - well, tank, river, rain, spring, impurities in water. Purification by decantation, filtration and boiling.

Pollution of water - disinfectants - bleaching powder and potassium permanganate.

- i. Collection of different samples of water of that locality
- ii. To observe pollution of water in the locality.
- iii. Experiment of decantation and filtration.
- iv. Experiment of action of alum on muddy water.
- v. To demonstrate disinfection of water.

III. Food

Necessary for growth and work. Diet for children, adults, manual labourers and sick persons.

Preservation of food-grains, vegetables and fruits.

Various methods adopted in the locality.

- i. To find the methods of preservation grains, vegetables and fruits,
- ii. To observe the timing of vessels.
- iii. To show that food articles can be preserved, boiling, cooling, drying and salting.

IV. House

Selection of site. Advantages and disadvantages of the various materials used in the construction of the house.

How to keep the house clear, ventilation and light.

- i. To visit places where bricks and lime-stone burnt.
- ii. Experiment of ventilation

V. How Science has benefited man:

Transportation - discovery of the wheel, carriages. Different kinds of power used - animal, steam, petrol, electricity.

Simple machines - Lever, Pulley, inclined plane, wheel and axle (gear) - friction and use of lubricants. Work of Newton.

- i. To drag up a log of wood and roll it and thus to observe that rolling is easier than dragging.
- ii. To observe that bus is driven petrol.
- iii. To visit a railway engine.
- iv. To draw water from a well with the help of a pulley and without its help.
- v. To observe the use of a crow-bar in lifting a heavy stone.
- vi. To observe that a road winds up a hill.

STANDARD VI YEAR

I. Air

Composition of air, preparation of oxygen and carbon-di-oxide in test tubes.

Reference to the work of Lavoisier and Priestly.

Oxygen supports combustion.

Carbon-di-oxide and Nitrogen do not support combustion;

Carbon-di-oxide turns lime water milky.

Air is purified by plants, sunlight and rain.

i. Expt. Bell-Jar experiment using candle

ii. To prepare oxygen by heating potassium chlorate in the test tube and to test with a red hot splinter.

iii. To prepare carbon-di-oxide by using washing soda and lemon juice or marble and dilute hydrochloric acid in a test tube.

iv. To pass carbon-di-oxide through lime water.

II. Water.

Properties of water - it seeks its own level.

Water supply in towns

Water cycle in nature.

i. Experiment to show that water finds its own level.

ii. Experiment to show that it flows from higher level to lower.

iii. To visit a town which has a protected water supply system.

iv. To draw a diagram to illustrate water cycle in nature.

III. Food.

Food contains starch, protein, sugar, fat, minerals, vitamins.

Balanced diet is better than any single food. Milk and egg are perfect foods.

Digestion in man and digestive system. Photosynthesis - plants prepare food in the presence of sunlight, liberate oxygen, take in carbon-di-oxide, manufacture starch.

i. To draw diagrams of alimentary canal to explain digestion.

ii. To prepare a balanced diet in school.

iii. Experiments to show that during photosynthesis -

a. oxygen is liberated;

b. carbon-di-oxide is taken;

c. starch is produced.

IV. Home.

White washing.

Sources of light - sun, oil, electricity - Nursing the sick.

i. To get the school white-washed.

ii. To study the houses in the neighbourhood from the point of view of ventilation and lighting.

iii. To visit a hospital.

V. How Science has benefited man.

- | | |
|---|--|
| Transportation by land-road and rail Locomotive by Stevenson. | i. To collect pictures of various kinds of transport in various countries. |
| By Sea - boat, sailship and steamship. By Air - Aeroplane, Work of Wright Brothers. | ii. To study a bicycle and its parts. |
| Compound machines - bicycle, sewing machine. | iii. To observe that one round of a pedal makes the free wheel go many rounds. |
| | iv. To compare the number of teeth in the pedal with those in the free-wheel. |
| | v. Repeat Expts. iii and iv with reference to the sewing machine. |

STANDARD VII YEAR

- | | |
|---|---|
| I. Properties of air - air has pressure. Air is compressible. | Expts. to show: |
| | i. That air crushes a thin tin when water is boiled in it and then its mouth closed air tight. |
| | ii. Inverted tumbler with water and a piece of card-board pressed against its mouth. |
| | iii. Observation of the walking of a lizard against a smooth surface |
| | iv. To blow air into a toy balloon and try to squeeze it. |
| | v. To observe tyres and tubes of a bicycle and a bus and to find out the effects of air pressure. |
| | vi. Soap bubble experiment. |

II. Water.

- | | |
|---|---|
| Water necessary for life. | i. To identify hard and soft waters by using soap solution. |
| Uses of water - drinking, cleaning, cooking. Hard and Soft water. | ii. To observe pressure of water in air. |
| Use of washing soda for softening water. | |

III. Food.

- | | |
|--|---|
| Blood and circulatory system. | i. To demonstrate the work of the circulating system with the help of charts and models. |
| Plants - Dispersal of seeds - Methods of improving the quality - cross pollination - Grafting. | ii. To observe the various methods of dispersal. |
| | iii. To visit an orchard and study the different methods of cross pollination and grafting. |

IV. Home

Sources of heat - Wood, charcoal, coal, oil and electricity.
Effects of heat - Expansion - change of states - change of temperature.
Three states of matter.
Thermometers - Centigrade, Fahrenheit and Clinical Communicable diseases -
Symptoms, modes, spread, prevention and control of plague, cholera, small pox, malaria, tuberculosis and leprosy.

Expt.-

- i. To show by heating that ice becomes water and water becomes steam.
- ii. To learn to use thermometers properly.
- iii. To note the readings of the thermometer in the school and record them.
- iv. To note the temperature of the human body with the help of the clinical thermometer.
- v. To collect posters and charts about these diseases and exhibit them.

V. How Science has benefited man:

Communication - post, telegram, radio - work of Marconi.
Power-driven machines - huller, tractor.
Eye - its main parts. Defects of eyesight.
Proper care of the eye.
Ear - its main parts - proper care of the ear.

- i. To collect stamps.
- ii. To visit a post office and a railway station.
- iii. To observe a tractor and a huller at work.
- iv. Expt. To show the formation of images by convex lens.
- v. To demonstrate the parts of the ear with the help of a chart.

APPENDIX II
(Continuation)

Ry 311

Allocation of time for General Science:

Allocation of time for Science ^{as suggested} by the All India Seminar
on the Teaching of General Science in the Higher Secondary Schools.

The Secondary Education Commission in their report have made
Mathematics and General Science as one core subject; but this
does not appear quite desirable. Grouping the two together will
lessen the importance and affect instruction in both. Since these
two subjects are of equal importance they should be treated as two
separate core subjects, and General Science alone should be allotted
the following number of periods:

In Class IX	4 periods a week or 141 periods in the year
In Class X	3 periods a week or 94 periods in the year.
In Class XI	2 periods a week or 75 periods in the year.

making in all 310 periods for General Science spread over a period
of three years.

APPENDIX III

Laboratory Organisation.

A Scheme for the Laboratory Organisation as suggested by the All India Seminar on the teaching of General Science in the Higher Secondary Schools.

Ref. Page- 310

The seminar considered the following aspects of laboratory organisation:

- (a) Lay-out
- (b) Equipment
- (c) Administration.

(a) Lay-out:

- i. A higher secondary school should have one General Science laboratory and three other laboratories for the three elective subjects, viz., Physics, Chemistry and Biology.
- ii. Each laboratory should have an over-all floor space of at least 30 sq.ft. per pupil.
- iii. Provision should be made for a store room for each laboratory adjacent to it as well as to the class-room.
- iv. A portion of the store room may be partitioned off to serve as a preparation room.
- v. There should be some suitable place for work-benches with tools in the Science wing.
- vi. At least two class rooms with galleried seats should be provided in each school.

(b) Equipment:

The Science class room should have the following equipment:

- i. Galleried seats.
- ii. A demonstration table about 8' x 8' with cup-boards, gas and water fittings.

The Physics Laboratory should have the following equipment:-

- i. Working tables with recesses underneath.
- ii. At least one table with gas fittings for experiments on heat.
- iii. Projected platforms preferably along one wall for balances.
- iv. Almirahs;
- v. Demonstration table with drawers, gas and water fittings.
- vi. A wall blackboard.
- vii. Two large sinks at the corners of the laboratory.
- viii. Stools in 2 sizes.

The Physics Laboratory should also have a drill room.

The Biology Laboratory should have the following equipment:-

- i. Tables, 6' long 2' wide and 2½' high with water fittings and drawers.
- ii. Almirahs.
- iii. Two sinks at the corners of the laboratory.
- iv. Wall blackboard.
- v. Stools in 2 sizes.
- vi. Small table racks.
- vii. Wall shelves for chemicals.
- viii. A froggery, where necessary.

The Biology Laboratory should be well-lighted. It should have glass-panes on the northern side and pendant lights over the tables.

(c) General.

The store rooms should be well-equipped with almirahs, racks and a sink. A separate shelter should be provided for inflammable and poisonous materials.

The larger schools should be provided with separate workshop with work benches and a tool cabinet. In smaller schools a few work-benches may be placed in the Science wing.

There should always be a first-aid set in a first-aid kit which is handy near the laboratories.

Provision should be made for an over-head projector and a gas plant for each school.

(d) Administration.

There should be a laboratory attendant for each laboratory with middle school qualifications and two store-keeper-scientist laboratory assistants for each school. The store-keeper-scientist laboratory assistant should be a matriculate.

Where there is enough work, a workshop should also be provided for the workshop. For the teaching of Physics, Chemistry and Biology, there should be at least one double period for each of these for practical work per week.

Experiments should be done as far as possible individually. In any case not more than two students should be grouped together for practical work in the elective sciences. However, in General Science groups of three students may be permitted for practical work.

To facilitate practical work, cards with brief instructions should be prepared for each experiment for the use of the students.

It is advisable to have a set of rules for the guidance of the students during their practical work.

Every pupil should maintain a laboratory note-book to record practical work, which should be regularly checked by the teacher.

A date-wise record of experimental work done by each pupil should be maintained by the teacher in the form of a chart.

APPENDIX IV

2. SCHOOLS FOR ORGANISING SCIENCE CLUBS.

1. A scheme evolved by the All India seminar on the Teaching of General Science, for the organisation of Science Clubs.

Ref. Page-531

Every school must have a Science club. These clubs are of the pupils by the pupils and for the pupils.

PURPOSE:

The following are some of the aims of Science club:

1. to inculcate a scientific attitude in the pupils.
2. to encourage the pursuit of science as a hobby.
3. to stimulate pupil-participation and initiative in learning Science.
4. to encourage pupils to take an intelligent interest in the environment and every-day experiences.
5. to encourage individual and group initiative.
6. to contact other Science clubs and to exchange information and activities.
7. to aim at a regional, leading to wider affiliation on state, national and international levels.

ORGANISATION:

1. The Science teacher, normally, will sponsor the club.
2. The head of the school should be a patron of the club.
3. Membership should be open to all pupils studying Science and others interested in Science
4. The resources of the school should be available to the club.

5. An elected executive committee should be formed from among the pupils - a chairman, a secretary, an assistant secretary, a treasurer, a librarian, a store-keeper, a publicity officer and class representatives.
6. A nominal membership fee should be charged from all the members.
7. The club should tap other resources etc.
8. The club should be located in the school.
9. The members of the club may be encouraged to extend the activities of the club in their own locality.
10. The duties of the patron, sponsor and office-bearers should be:

Patron: To extend all facilities to the club to function effectively and co-operatively in its activities.

Sponsor: On the sponsor devolves the initiative in starting the club and he initiates it at a high pitch of activity and interest. The sponsor should only supervise, guide and lead and should not instruct or dictate. He should be watchful over the members and guard them against accidents.

CHAIRMAN: to preside over all the formal functions of the club and over the meetings of the executive committee.

Secretary: to maintain the minutes of meetings and the activities of the club; to carry on correspondence, invite guests.

Assistant Secretary: to assist the secretary and to act for him in his absence.

Treasurer: to collect subscription and maintain accounts of receipts and expenditure.

Librarian: to maintain a catalogue of the library, to issue and receive books, to purchase books sanctioned by the executive committee, file and keep a record of the papers written by the members of the club.

Store Keeper: to maintain a record of the equipment of the club, to buy new equipment sanctioned by the executive committee.

Publicity Officer: to publicise the activities of the club within and without the school: to contact newspapers and seek wide publicity for the activities of the club, its meetings, its magazines, its celebrations (exhibition, fair etc).

Members: to participate actively in the meetings of the executive committee, in framing policies, to enlist the co-operation of the members of the class and to enlist new members.

SUGGESTED ACTIVITIES:

The following are some of the activities that should be undertaken by a Science club.

1. arrange excursions, visits to places of interest etc.
2. hold Science exhibitions and fairs.
3. conduct the meteorological section of the school.
4. hold discussions, meetings and debates.
5. to read papers on individual or group work done.
6. to collect specimens, preserve models, charts, exhibits and maintain a scrap book.
7. to improvise and prepare hand-made apparatus.
8. to improvise experiments.
9. to celebrate Science days and put up tableaux, plays.
10. to hold meetings addressed by invited guests.
11. to render school service in health and sanitation.
12. to render community service in the realm of public health.

13. to organise drives to inculcate sound health habits.

14. to attempt to eradicate superstition and age-old taboos.

ALL INDIA ASSOCIATION OF SCIENCE CLUBS:

In view of the importance of the Science Club activities as outlined above, an All India Association of Science Clubs, should be formed under the auspices of the A.T.C.S.I.

APPENDIX IV

2. ORGANISATION OF SCHOOL CLUBS:

A scheme for the organisation of School Science clubs,
evolved by the General Science Seminar held in Varanasi
during November, 1958.

Ref. Page- 531

(A) As suggested by the All India Council for Secondary Education

1. The Science Teacher, normally, will sponsor the Club.
2. The Head of the School should be a patron of the Club.
3. Membership should be open to all pupils studying science and others interested in science.
4. The resources of the school should be available to the Club.
5. An elected executive committee should be formed from among the pupils, - a chairman, a secretary, assistant secretary, a treasurer, a librarian, a store-keeper, a publicity Officer and class representatives.
6. A nominal membership fee should be charged from all the members.
7. The club should tap other resources also.
8. The Club should be located in the school.
9. The members of the club may be encouraged to extend the activities of the club in their own locality.
10. The duties of the Patron, Sponsor and Office-bearers should be:

PATRON: To extend all facilities to the club to function effectively and co-operate in its activities.

SPONSOR: On the Sponsor devolves the initiative in starting the Club and keeping it at a high pitch of activity and interest. The sponsor should only supervise, guide and lead and should not instruct

or dictate. He should be watchful over the members and guard them against accidents.

CHAIRMAN: To preside over all the formal functions of the club and over the meeting of the Executive Committee.

SECRETARY: To maintain the minutes of meetings and the activities of the club; to carry out correspondence; invite guests.

ASSISTANT SECRETARY: To assist the Secretary and to act for him in his absence.

TREASURER: To collect subscriptions and maintain accounts of receipts and expenditure.

LIBRARIAN: To maintain a catalogue of the library; to issue and receive books; to purchase books sanctioned by the executive committee and to keep a record of the papers written by the members of the club.

PUBLICITY OFFICER: To publicise the activities of Club within and without the school; to contact newspapers and seek wide publicity for the activities of the Club, its meetings, its magazines, its celebrations (exhibitions, fair etc).

MEMBERS: To actively participate in the meeting of the executive committee in framing policies, to enlist the co-operation of the members of the class and to enlist new members.

(B) Modifications suggested:

Some sponsors experienced a great difficulty in connection with the number of students joining Science Club, hence the group suggested

the following modifications in item No.2.

Though the membership should be open to all but it should be of two types.

i. ORDINARY MEMBERSHIP: Those who pay rupee one per annum as membership fee will be considered ordinary members. They will not be entitled to work in the science club laboratory but will be eligible to participate in all other activities of the club.

ii. ACTIVE MEMBERSHIP: The active membership will be confined to pupils who exhibit an urge and zeal to do and learn more and will be selected from amongst the ordinary members or the recommendations of the sponsor and members of the advisory committee. These members will have to pay annas four per month as membership fee and will be entitled to work in Science club laboratory.

Activities of Science clubs:

The group held discussions on the activities of a Science club and suggested three types of activities which could be undertaken by the members of a Science club, They are:

A. COLLECTING ACTIVITIES: Members of the club should be advised to collect the following:

1. Seeds, fruits, leaves, flowers, grass, ferns etc.
2. Insects, birds, eggs, sea shells, sea weeds, reptiles etc.
3. Soils, minerals, rocks, herbs, crystals, fertilizers, etc.
4. Mechanical toys, models, etc.
5. Dyes, medicines, etc.
6. Photographs, pictures etc.

N.B: Proper arrangements should be made to store them and preserve them. These activities may be undertaken by ordinary members.

(B) WORKSHOP ACTIVITIES: Active members should be asked to undertake the following activities:

1. Preparation of various types of models. Illustrating the principle and their application.
2. Up keep of aquarium, vivarium and beehives.
3. Construction of improvised apparatus.
4. Preparation of various solutions for removing various types of stains.
5. Run a weather bureau.
6. Preparation of simple things of every day use such as cosmetics, antiseptics, paints, polishes, etc.

(C) SPECIAL ACTIVITIES: Both ordinary and active members will participate in these activities. They will be of the following nature:-

1. Organising excursions and field trips.
2. Arranging exhibitions and fairs.
3. Celebrating the scientist days.
4. Holding debates, discussions and lectures etc.

Maintaining Records:

For the successful running of a Science Club it is essential that records of various programmes and activities be maintained properly and satisfactorily. The group suggested that the following record books be maintained by all the science clubs:-

1. Record Book for membership: In this book full particulars of members ~~at~~ e.g., names, standard, subscription, project

undertakings should be maintained.

2. Project Record Book: In this book full particulars of projects should be shown:

- a. Name of the project;
- b. Participants;
- c. Material required;
- d. Sources of material;
- e. Lists of books etc;
- f. Follow-up work etc. etc.

3. School Registers.

4. Account Books:

5. Record of correspondence:

6. Any other record which is considered useful.

Practical Difficulties.

A. Untrained Sponsors: This was analysed into two aspects (i) the psychological approach to running of science club activities (2) lack of technical knowledge needed. The solutions to these difficulties were suggested. Mention is made of the following:

(a) Large number of seminars, conferences and work-shops are being held these days to suggest various psychological approaches to organise curricular and extra-curricular activities. It is suggested that teachers be given ample opportunities to attend these.

(b) Knowledge and Range of Science club activities is very large, there would always be occasions when the teacher is lacking the technical knowledge and certain things. Therefore, the teacher should always have the attitude of a learner and treat the members of the club as co-workers in projects. He should enthuse the pupils by his scholarly attitude. Science activities will also need a

better preparation on the part of the teacher and that teachers should learn to handle these tools and keep an account of their journals and books of current interest. If possible, local scientists may be invited to demonstrate the use of tools.

B. OVER BURDENING OF SCIENCE CLUBS:

a. This can be minimised by enlisting the cooperation and participation of enthusiastic students and by encouraging them to take up some responsibilities.

b. All possible facilities should be provided to the science teacher, so that he may not be led to feel it as an extra load for him, for in that case the whole purpose and aim of the science club will be defeated and it will degenerate into an additional science class.

C. OVER CONSUMING IN SCIENCE CLUBS:

In this respect it was suggested that the time and facilities provided in the club may be properly budgeted for utilization by the pupils. And the claims of each student may be properly scrutinised and it may be suggested to them to utilize community resources whenever possible.

APPENDIX V

SAMPLES OF INSTRUCTION SHEETS FOR LABORATORY WORK.

Ref. Page 270.

SAMPLE I.

i. The Density of a Substance 'lighter' than water.

EXPT.8 - To find the density of a bottle-cork.

Appratus: Cork, glass measuring cylinder.

Method: Partly fill cylinder with water.
Read water level.
Let the cork float in the water.
Read water level.
Push cork just under the water with a long
pointed instrument (e.g. compass).
Read water level while cork is submerged.
Calculate WEIGHT of cork from displacement while floating.
Calculate VOLUME of cork from total displacement when
submerged.
Calculate DENSITY of cork.

In note-book write number and title of expt.

Leave ten lines blank and then record measurements and calculations thus:

	First water level	-	-	-
	Water level, cork floating	-	-	-
	Water level, cork submerged	-	-	-
∴	Volume displaced when floating	-	-	-
∴	WEIGHT of cork	-	-	-
	Volume displaced when submerged	-	-	-
∴	VOLUME OF cork	-	-	-
∴	Density of cork	-	-	-

In space left blank write an exact description, in order, of how the experiment was carried out.

-H.N. Saunders

APPENDIX V

Sample 2

Observation of a biological specimen.

EXPT. 26. - To examine the wing of a bat.

Provided: A dead bat.

In a note-book, write number and title of experiment and then write the answers to the following questions:

- (a) What is the length of the bat from head to tail?
- (b) What is the length of each wing when fully stretched out?
- (c) How many 'fingers' are used to keep the wing in shape?
- (d) Is there a 'fifth finger'? if so, what is its shape?
- (e) For what purpose might this 'fifth finger' be used?
- (f) Are there any feathers on the wing?
- (g) What does the wing feel like to touch?
- (h) Are the wings attached to the body of the bat?
- (i) Are the hind legs attached to the wings?
- (k) Is there anything else to notice about the wings?

Draw the wing as it appears when stretched out.

APPENDIX V.

Sample 3.

Does saliva react with starch?

EXPT.1 - To examine the action of saliva on starch

Provided: Starch solution, iodine solution, test-tubes, watch-glasses.

Prepare: Saliva solution according to instructions.

Method: Place a drop of iodine solution in each of eight watch-glasses.

Mix equal quantities of starch and saliva solutions in a test-tube; note the time. Using a clean glass tube extract a drop of the mixture and place in watch-glass 1. Note any colour change. After half a minute extract another drop of the mixture, using a clean glass tube, and place in watch glass 2. Note any colour change. After one minute from the time of mixing, and with a clean tube, extract another drop of the mixture and place in watch glass 3. Note any colour change. Repeat the process, each time with a clean tube, 2 min., 5 min., 10 min., 30 min. after mixing. in the other watch-glasses.

Control experiment:- Test the original starch solution at the beginning of the experiments, and after it has been standing for 30 minutes unmixed with saliva. (Place a sample in each of two other watch-glasses containing a drop of iodine solution, and note any colour changes.)

Write the number and title of the experiment in note-book, describe it, and record the results in a table thus:

Saliva acting for:	Colour with iodine.	conclusion.
0 min.	blue	starch present
1 min.	blue	starch present
1 "		
2 "		
5 "		
10 "		
20 "		
30 "	brownish	starch absent.

Control expt: Starch solution and iodine.

At beginning (blue coloration)

Conclusion (starch present)

Starch solution and iodine

after 30 min. (blue coloration)

conclusion (starch unchanged)

General conclusion: (Saliva causes starch to change into something else).

- H. N. Saunders

APPENDIX VI.

SAMPLES OF QUIZ CARDS.

Sample 1

QUIZ CARD	ANSWERS
1. What is the speed of sound in air?	1100 ft. per sec.
2. An apparatus with a name ending in '-scope' shows something; an apparatus with a name ending in '-meter' measures something; e.g. compare the names 'thermoscope' and 'thermometer'.	Microscope Micrometer or Spectroscope Spectrometer.
3. Name two organs of the body mainly concerned with purifying the blood.	Liver Kidneys
4. What element most closely resembles sodium?	Potassium
5. What colour is outside arc of a rain-bow? Give the initial letters of the seven colours of the rainbow in order.	Red V.I.B.G.Y.O.R.
6. What instrument is used to measure the length of a curved line?	Opisometer
7. State the formula used to represent Ohm's law.	$V=CR$, or $\frac{V}{C} = R$, or $\frac{V}{R} = C$
8. At what temperature does ether boil?	35° C
9. Name the three parts of vascular bundles in plant stems.	Wood, cambium, bast
10. What name is given to a wheel which turns about a point not its centre?	Cam, or eccentric

- H.N. Saunders

APPENDIX VI.

Sample 2.

-
- | | |
|---|---|
| 1. What name is given to the place where a collection of dried plants is kept? | Herbarium |
| 2. How many petals has a (named local) flower? | ... |
| 3. Is saliva acid or alkaline? | Alkaline |
| 4. What name is given to the instrument that measures the speed of the wind? | Anemometer |
| 5. Are bats blind? | No |
| 6. What kind of naturally occurring water is likely to be the purest? | Rain water |
| 7. Which two colours make (a)purple?
(b)Peacock? | Red and blue
Green and blue |
| 8. What are the limits of human audibility? | 20 to 20,000 vibrations per second approximately. |
| 9. What instrument is used to measure the inside or outside diameters of tubes. | Callipers |
| 10. Name the long-handled sharp knife used in making dissections. | Scalpel |
-

- H.N. Saunders

APPENDIX VI.

Sample 3.

- | | |
|--|-------------------------------|
| 1. What instrument measures the radius of curvature of a spherical object? | Spherometer |
| 2. Who first worked out calculations about 1 verse? | Archimedes |
| 3. What single word describes a piece of or partly of cotton, rubber, sulphur wood and silk? | Insulator |
| 4. What are the three main constituents of food? | Carbohydrates, fats, proteins |
| 5. Into what class do biologists put dormice, rats, mice, squirrels? | Mammals |
| 6. How many seed leaves has maize? | Two |
| 7. What is the chemical formula for sodium bicarbonate? | NaHCO_3 |
| 8. From what is bleaching powder made? | Sulphur dioxide and chlorine |
| 9. Which are the highest cloud formations? | Cirrus |
| 10. How are watts, amperes and volts connected? | $W = CV$ |

- H. N. Saunders

APPENDIX VII

A course of lectures and practical work designed for the two year part-time certificate course in the 'Teaching of Science' in the University of London Institute of Education for trained teachers. This includes lectures, seminars, laboratory practice and the study of basic science subjects. Ref. Page 415.

A. LECTURE COURSE:

I. History and Philosophy of Science:

1. Science in the ancient world.
2. Copernicus and new world view.
3. Physics and the modern world.
4. The nature of matter.
5. The contribution of Harvey to Science.
6. The contributions of Linnaeus to science
7. Public health and its economic implications.
8. Science in the twentieth century.

II. Contents and Methodology of Science:

1. Aims of Science teaching.
2. Changes in the educational ideas underlying science teaching since 1850.
3. The science syllabus in relation to personal and environmental factors involved.
4. Techniques of science teaching.
5. A study of the topic 'water'.
6. Equipping the Laboratory.
7. Varieties of teaching methods.
8. Laboratory maintenance

9. Science clubs and Science Libraries.
10. Field work, school visits, expedition, museums, etc.
11. Apparatus making.
12. Laboratory precautions - the law on the teacher.

B. PRACTICE WORK:

1. Glass blowing
2. Syllabus study.
3. Laboratory practice.

C. DESIRABLE SCIENCE:

1. A course in Biology
2. A course in Physics
3. A course in Chemistry, etc.etc.

APPENDIX VIII

Syllabus in Natural Science prescribed for the duration of the 3rd Year course for the teachers undertaking, in the St. Louis Training College at Cheltenham in England, during 1957-58.

Ref. Page 373

ECOLOGY

20 meetings, each of five and a half hours duration.

1. The elements of structure; zoology and the cell.
2. Food, capture, capture by animals, digestion in man, the alimentary canal.
3. Photosynthesis; chemosynthesis. Leaf structure.
 - The release of energy in living organisms; outline of cellular respiration.
4. Respiratory organs in the animal kingdom.
5. Respiration in plants - continuation of plant structure.
6. Circulation in animals, especially man. Dissection of vertebrate.
7. Conduction in plants. Transpiration
8. Excretion in plants and animals. The structure and physiology of mammalian kidney. Osmotic regulation of the internal environment.
9. Reproduction in animals; introduction to genetics; physiology of mammalian system; outline of animal development; sex teaching.
10. Reproduction in plants: spores and seeds; floral structure and classification; pollination.
11. Genetics; outline of essential work.
12. Evolution; the evidence from animal affinities, palaeontology, and geographical distribution.
13. Irritability. Co-ordination in animals; hormones; nervous system.

15. Plant movement.

Some thirty lectures on these subjects are accompanied by appropriate practical work, the latter occupying about 1 hour work and including field studies related to the above. Although these field studies students are given some acquaintance with the variety of organisms, their inter-relationships, and the basis of classification in both plant and animal kingdoms.

During the year, students are expected to conduct a special study on "Parasitism" and one on "Trees".

Gardening

20 meetings, each of one and a half hours duration.

Lecture - demonstrations on the following, followed by individual practical work:-

1. The soil.
2. Manures and fertilisers.
3. Propagation from (i) seed, (ii) hard wood and soft stem cuttings, (iii) budding and grafting.
4. The uses of frames, cloches, and greenhouses in school work.

In addition, lecture-discussions on:

1. Aims and limitations of gardening in schools, The syllabus.
2. The school garden.
3. Plot experimental work.
4. The link with Nature Study and General Science. Laboratory work.
5. Literature. Sources of material. Visual aids.

This section also includes a consideration of Farm Studies in the Secondary Modern school. In conjunction with this visits are made to Hartpury Farm Institute and Whalley Farm. And oversford.

Chemistry

30 meetings, each of four hours duration.

Term I.

Lecture	Practical.
1. Water; to serve as a revision of some terms and an introduction to new ones.	Water, Constituents. Hydrogen. Oxygen. Hydrolysis. Hydrogen peroxide. Disinfectant uses.
2. Classification of Chemistry The Periodic Table	Electrolysis; uses and importance
3. Pot ls - outline only; students construction of scheme for use in schools when treating this topic.	
4. Atomic structure; outline of present ideas to Bohr Model. Ions.	The hydrogen ion; its behaviour and determination of pH colorimetrically.
5. Valency. Idea of directed bonds; electronic theory.	
6. The group Separation of Cations	Analysis for 2 radicals
7. Theory of the process.	Further analyses of progressive difficulty
8. Tests for acid radicals	Practice of tests.

Term II.

1. Types of chemical compounds - Hydrides and oxides	Study of the non-metals P, S, N, Cl. Additional properties of gases.
2. Oxides, Hydroxides, Halides	Summary of general properties of gases.
3. Sulphides and Oxydsalts.	Volumetric analysis. Standard solutions.
4. Atomic structure continued. Outline of the relationship between this and chemical behaviour.	Volumetric - acid, alkali titrations
5. ditto.	Volumetric - determination of halides by silver nitrate.
6. Catalysis - outline only. Students to prepare as special display.	Additional practical may be set according to individual needs

Term III

1. The element carbon. Unique position and properties. Chief classes of its compounds. Organic radicals. The properties of the most common carbon compounds; the behaviour of radicals. Some important industrial reactions.
2. Fuels. Coal, petrol, alcohols. -ditto-
3. Explosives. Phos, explosion, energy involved. -ditto-
4. Dyes, plastics, synthetic fibres. Preparation of an azo-dye, a synthetic plastic. Properties of these materials.
5. Chemical change in moral - to serve as a summary of the course. Completion of any work.
6. The scope of chemistry in the school curriculum.

The practical work occupies two and a half hours each.

GEOLOGY

25 meetings of one and a half hours each on Monday and Saturday throughout the course.

Term I.

- | | | |
|------------|--------------------------|---|
| 1. Week 1. | Monday. BBC
Saturday. | What is a fossil?
Earth's crust; the lithosphere. |
| Week 2. | Monday. BBC
Saturday | Why fossils are found in land.
Minerals and rocks; a chemical basis of mineral classification. |
| Week 3. | Monday BBC
Saturday | Going ashore
Rock-forming minerals (Si - Al) |
| Week 4. | Monday. BBC
Saturday | Life in the Coal-Age forests
Rock-forming minerals (Si - Fe) |
| Week 5. | Monday BBC
Saturday | Reptiles conquer drought
Useful minerals, ores and veinstones. |
| Week 6. | Monday BBC
Saturday | Giant reptiles, rule the world
Useful ores and veinstones. |
| Week 7. | Monday. BBC
Saturday | Living things change
Classification of rocks. |

Week 7.	Monday. BBC Saturday	Dating the rocks Sedimentary rocks
Week 8.	Monday. BBC Saturday	Brain, eye, and hand Crystalline rocks
Week 10.	Monday. BBC Saturday	Apes and men Rocks and time.

Term II.

Week 1.	Monday and Saturday.	Biological and Geological classifica- tions.
Week 2.	..	First and last animals in the geolo- gical record
Week 3.	..	Palaeozoic fossils
Week 4.	..	Mesozoic and Tertiary fossils
Week 5.	..	Field work; Icehampton Hill and Battle Down Brickworks.

Term III.

Week 1	..	Pre-Cambrian Era: Distribution, Scenery and types of Pre-Cambrian rocks e.g. Malvern Hills
Week 2	..	Lower Palaeozoic era; rock sequences, life of the time, scenery and general uses.
Week 3	..	Upper Palaeozoic era; ditto.
Week 4	..	Field work; Malvern
Week 5	..	Field work: Malvern or Cheltenham sands and Severn terraces.
Week 6	..	Mesozoic era
Week 7	..	Tertiary era
Week 8	..	Quaternary era

Physics

30 meetings of four and a half hours.

Term I.

1. What is Physics? Origin and development.

2. Physics as the study of measurement. Fundamental quantities, their units and methods of measuring; definitions of force.
3. Physics as the study of energy. Sources of energy; their nature and inter-relationships.
4. The physics of music. (a) Wave-motion - essential properties and how they are illustrated by sound. Pitch, loudness, quality
5. The physics of music (b) Instruments - their principles and properties, Human voice and ear.
6. Fundamentals of magnetism and electricity.
7. Elementary A.C. Electro-magnetic induction and the A.C. generator. R.M.S. values of current and voltage.
8. Fundamentals of optics. Propagation of light, sources, reflection, refraction, lenses.
9. The photographic camera. (a) The lens - detailed function aberrations.
10. The photographic camera (b) Stops and shutters, view and rangefinders, filters, special cameras.
11. Other optical instrument. Projector, telescope, microscope, binoculars, eye.

Term II. The composition of the electro-magnetic spectrum.

1. Gamma-rays. Source, nature of fission and radioactivity.
2. X - rays. Source, properties, work of Rontgen and Moselley, structure of the atom, energy levels.
3. U.V., Visible light, and I.R. Sources and properties. types of spectra and use, origins of spectra.
4. Radio waves. Source and reception, elementary radio.
5. Prelude to teaching practice - suggestions on specific problems concerning students.

Term III.

1. Elements of mechanics. Pulleys, levers, gears.
2. Physical properties of liquids with particular reference to Water. Mechanical, density, pressure, hydraulics, flotation surface tension, viscosity.

3. Thermal properties of liquids. Expansion, change of state, evaporation - including refrigeration, vapour pressure and humidity.
4. Ultrasonics. Film and discussion.
5. Colour. Nature, production, colour vision, colour printing.
6. The chemical effect of an electric current. Including cells and the maintenance of accumulators.
7. Elementary astronomy. The solar system, star systems and moons.
8. Further electronics. More detailed circuitry than that covered above.

Three hours each week is devoted to practical work which is assigned on an individual basis according to need, the background of the group varying so widely. The experiments are designed to emphasise essential principles, valuable techniques, and suitable demonstrations. Attention is also given to work suitable for group activity by classes containing children of widely differing ability and inclination.

In addition, each student is expected to prepare a detailed scheme of work, including demonstration experiments and outline lesson notes, on a selected topic (List available on application).

During Term III, short courses in Practical Photography and Elementary Meteorology are held at times to be arranged by mutual agreement.

The Philosophy and Methods of Science, History of Science.

30 MEETINGS; EACH OF THREE QUARTERS OF AN HOUR.

The aim is to stimulate thought about the nature of science. Except in the section dealing with the History of science, the lecturer discourages the idea of taking notes for memorising and reproduction.

1. What is science? Content and method. Relation to other fields.
2. Aims and limitations of science.
3. Scientific method. The main steps.
4. Observation and records.
5. Hypotheses. Nature. Study of some simple cases and some of historic importance.
6. Experimental testing of hypotheses.
7. Science and Mathematics.

The History of Science

1. Early and classic science.
2. Mediaeval ideas.
3. The foundation of Mechanics. Galileo and Newton.
4. Copernicus and astronomy.
5. The growth of chemistry. The phlogiston theory. Atoms and molecules.
6. Heat and Energy.
7. Electricity.
8. Biological developments; medical applications.
9. Darwin and Evolution.
10. The revolution in modern physics.

Statistics

25 meetings, each of three-quarters of an hour.

1. Ideas of Probability.
2. Simple calculations of chance, including examples from genetics.
3. Illustrations of probability in modern science.
4. The problem of marking.
5. Distributions, Graphical representation. Some types of distribution.
6. Central tendencies. Mean.

7. Standard deviation.
8. Standardisation of marks and scores.
9. Binomial and normal distributions. Use of tables.
10. Correlation. Calculation by product - moments and indication of other methods.
11. Significance and interpretation of correlation.
12. Sampling and sampling errors.
13. Error of mean of observations.
14. Chi - squared test and some idea of other procedures.

The treatment of all this material has regard to school use and is essentially simple.

Visual Aids.

Section I. Non-projected aids. Display and layout.

17 meetings each of one and a half hours duration.

The aims of this Section are:

Study and practice in the use of colour, pattern and texture
Enlargement of skill in the use of lettering and handwriting
Development of observation and free drawing skill.

1. Introduction to materials and discussion of work.
2. Handwriting practice, Demonstration precedes practical
3. Making of simple folder to contain course work.
Samples of simple folder and bookcraft displayed and explained.
4. Simple lettering. Proportions of letters. Spacing.
5. Play with colour. Tints and shades. Use of primaries in mixing.
6. Proportion and Contrast experiments. Value of counterchange.
7. Use of pattern and texture. Making their own
8. Use of pattern and texture. Design from collected materials.
9. Production of Visual Aid for teaching some aspect of science using cut-outs and cut out lettering.

10. Production of a Science Display using freehand drawing, brush or pen-lettering.

The folder made in (3) above is considered throughout as an exercise in Display and Layout.

Section II Projected Aids.

7 meetings each of three-quarters of an hour duration, following by the use of equipment at appropriate places throughout the course.

1. Episcopes. Principle and uses.
2. Diascopes. Layout, path of light, uses.
3. Film and slide projectors.
4. Film strips and film loops.
5. Cine-film projection. Silent and sound films.
6. The analysing cine-projector.
7. Screens.

Sections I and II are held at the beginning of the course, and both are completed before students begin their period of teaching practice.

Section III Practical Photography.

1. The camera; modifications for special purposes.
2. Film. The different types and their respective uses.
3. The process of development; fixing.
4. Printing and glazing.
5. Enlargement.

A maximum of 8 meetings each of one and a half hours duration, to be devoted to this work in Term III.

A critical examination of a selection of science films and film-strips is undertaken in Term III during two of the weekly Colloquia.

Use of Materials - Workshop Practice.

20 meetings, each of one and a half hours duration.

Term I. Wood.

Term I. Wood.

1. Nature of common woods; tools used; mode of operation. (Lecture-demonstration)
2. Manipulation, marking out, cutting (including circular saw for home use.) Demonstration and practical.
3. Fixing wood to wood: nailing, screwing, adhesives. Demonstration and practical.
4. Construction of simple article using this information.
5. Microscope slide box, for example.

Metals.

1. Metals used for constructional purposes; tools used (Lecture - demonstration)
2. Manipulation of sheet metal. Bending, cutting, folding. (Demonstration and practical).
3. Fixing metal to metal. Bolting, riveting, brazing, welding. (Demonstration and practical)
4. Fixing metal to non-metal. Drilling, screwing, bolting, riveting, adhesives. (Demonstration and practical)
5. Completion of above and construction of small metal tray.

Term IV. Glass.

1. Types of glass; mode of cutting - file and hot wire; the blow pipe, (Lecture - demonstration followed by practical)
2. The union of two and three pieces of glass of equal diameter, e.g. latterly making T-pieces. (Lecture demonstration followed by practical)
3. The union of two pieces of glass of unequal diameter. Bending glass tubing. (Lecture demonstration followed by practical).
4. Sealing glass tubes, blowing bulbs, drawing out jets, making a small flask (Lecture demonstration followed by practical).
5. Completion of above. Practical exercises on glass-working.

Term III. Plastics.

1. Plastics used for constructional purposes - particularly Perspex. Properties; tools used. (Lecture demonstration)
2. Identification. Working, cutting, bending, moulding. (Lecture demonstration and practical)
3. General plastics. Construction of simple devices as parts of apparatus. (Lecture demonstration and practical)
4. Use of plastics in the preservation of specimens. The technique of embedding. (Lecture demonstration and practical)
5. Correlation of above.

ANNEX II

Statement of Policy by the Government of India with regard to
Science and Scientific research. Ref. Page 76, XV

A statement indicating the policy of the Government of India with regard to science and scientific research is announced on March 12, 1952 in a resolution placed before both Houses of Parliament.

- i. To foster, promote, and sustain, by all appropriate means, the cultivation of science, and scientific research in all its aspects - pure applied and educational;
- ii. To ensure an adequate supply, within the country, of research scientists of the highest quality, and to recognise their work as an important component of the strength of the nation;
- iii. To encourage and initiate, with all possible speed, programmes for the training of scientific and technical personnel, on a scale adequate to fulfil the country's needs in science and education, agriculture and industry and defence;
- iv. To ensure that the creative talent of men and women is encouraged and finds full scope in scientific activity;
- v. To encourage individual initiative for the acquisition and dissemination of knowledge, and for the discovery of new knowledge in an atmosphere of academic freedom;
- vi. And, in general, to secure for the people of the country all the benefits that can accrue from the acquisition and application of scientific knowledge.

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APPENDIX X

A LIST OF CENTRAL & NATIONAL LABORATORIES & INSTITUTES OF INDIA (1958)

Ref. Page 561

S.No.	Name of Laboratory.	Location.	Functions.
1.	National Chemical Laboratory, Poona.		Fundamental and applied research covering the whole field of chemistry for which other specialised institutes have not been set up. The National Collection of Type Culture is housed in the Laboratory.
2.	National Physical Laboratory.	New Delhi	Research in problems relating to physics, both fundamental and applied. Maintenance of standards. Testing facilities are also available.
3.	Central Fuel Research Institute.	Jeaingora(Bihar)	Fundamental and applied research on fuels - solid, liquid and gaseous. Physical and chemical surveys of Indian coals are conducted through six coal survey stations under the Institute.
4.	Central Glass Ceramic Research Institute.	Jadavpur	Research on different aspects of glass and ceramics, pottery, porcelain, refractories and enamels; development of processes for the manufacture of glass and ceramic articles; standardisation of raw materials used in the ceramic industry.
5.	Central Food Technological Research Institute.	Mysore	Food processing and conservation of foods, food engineering and all aspects of fruit technology.
6.	National Metallurgical Laboratory.	Jamshedpur	Fundamental and applied metallurgical research.

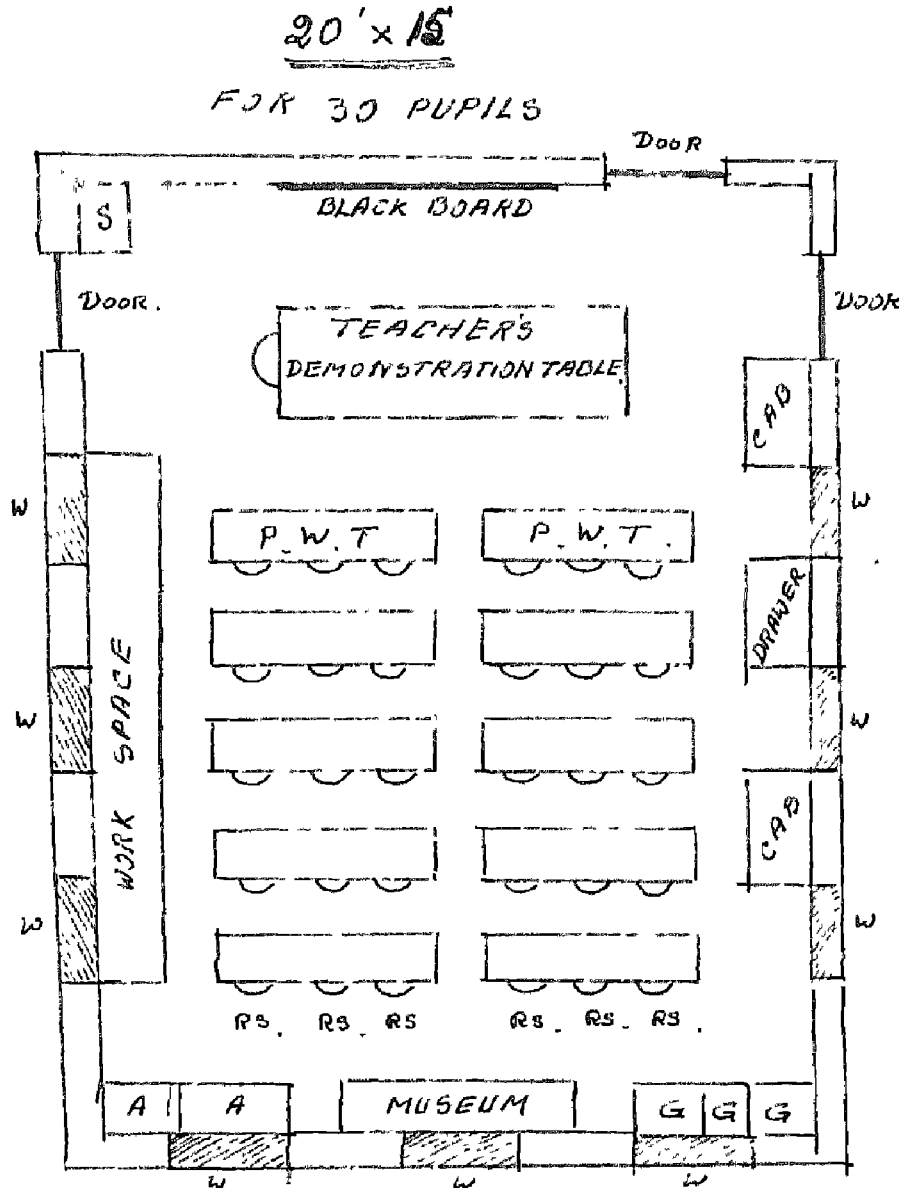
Sl.No.	Name of Laboratory.	Location.	Functions.
7.	Central Drug Research Institute.	Lucknow.	All aspects of drug research including evaluation and standardisation of drugs, discovery of substitutes for pharmacological uses and plants pharmaceutical and synthetic chemicals, biochemistry and biophysics, infection, immunisation, chemotherapy, chemotherapy and experimental medicine.
8.	Central Road Research Institute.	New Delhi	Research on road materials, testing of road materials and road surfaces.
9.	Central Electro-Chemical Research Institute.	Karaikudi (Madras)	Research on different aspects of electro-chemistry, including electrowinning, electro-deposition and applied problems.
10.	Central Leather Research Institute.	Madras	Fundamental and applied aspects of leather technology.
11.	Central Building Research Institute	Roorkee	Engineering and structural aspects of building and human comforts in relation to buildings.
12.	Central Electronics Engineering Research Institute.	Pilani (Rajasthan)	Design and construction of electronic equipment and components and test equipment.
13.	National Botanical Gardens	Lucknow	Collection, introduction and large-scale cultivation of economic and medicinal plants of industrial importance.
14.	Central Salt Research Institute	Bhavnagar	Investigation of production of pure salts, reduction in cost of production; economic utilisation of byproducts of salt manufacture.
15.	Central Mining Research	Dhanbad	Research on methods of mining, safety in mines and mine machinery.

Sl.No.	Name of Laboratory.	Location.	Functions.
16.	Regional Research Laboratory.	Hyderabad	Research in problems specially relating to the industries and raw materials of the area.
17.	Indian Institute for Biochemistry & Experimental Medicine.	Calcutta	Research in various aspects of biochemistry as applied to medicine, bacteriology, etc.
18.	Birla Industrial & Technological Museum.	Calcutta	A museum to depict scientific and technological advancement.
19.	Regional Research Laboratory.	Jammu-Tawi (Jammu & Kashmir)	Research in problems specially relating to the industries and raw materials of the area and research specially directed to medicinal plants of the Himalayas (Kashmir region).
20.	Central Technical Engineering Research Institute.	Durgapur (W.Bengal)	Research in technical engineering in all its aspects.
21.	Central Public Health Engineering Research Institute.	Muzam	Research in all aspects of public health engineering and co-ordination of work of all interested agencies in this field in the country.

APPENDIX XI - LABORATORY DESIGNS

I. ~~Sample of~~ A plan for our Primary School Science Room:

Ref. Page - 322

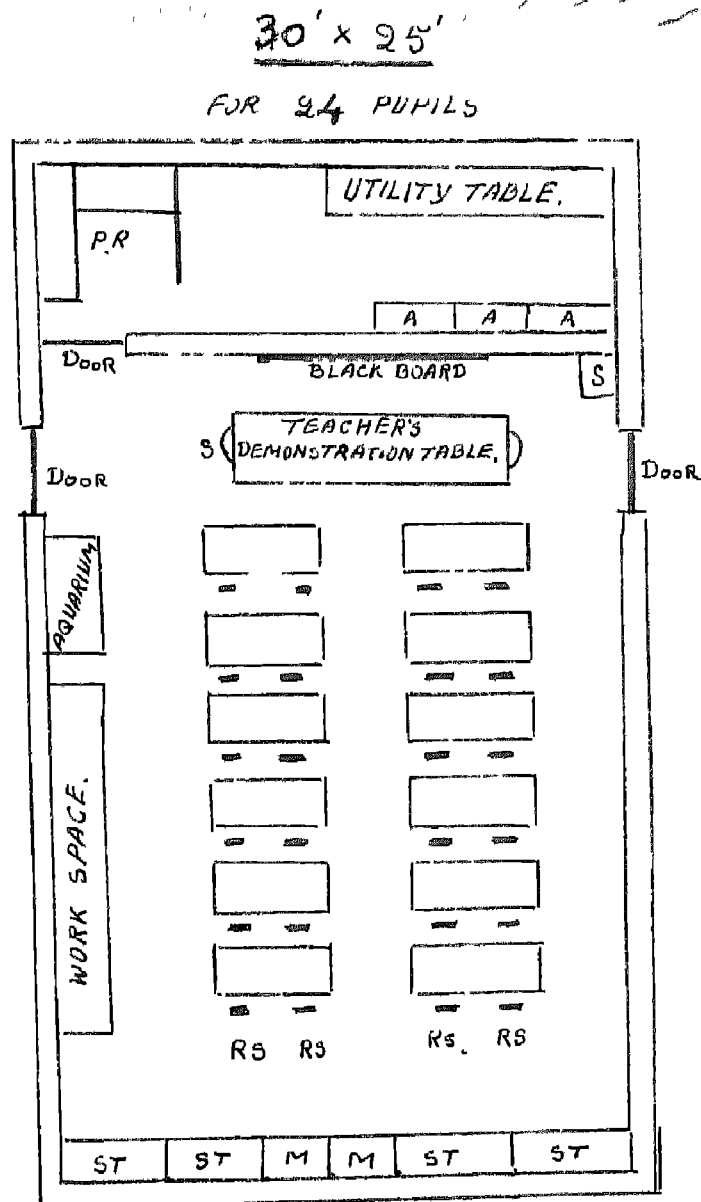


Size 20' x 15'

G	...	Germination Box
A	...	Aquarium
S	...	Sink
CAB	...	Cabinet
P.W.T.	...	Pupils' Work Table.
B.B.	...	Black Board
R.S.	...	Raised Seats

Accommodation for 30 pupils.

II Sample Plan for the High School General Science Laboratory: (Page - 311)



Size - 30' x 25'

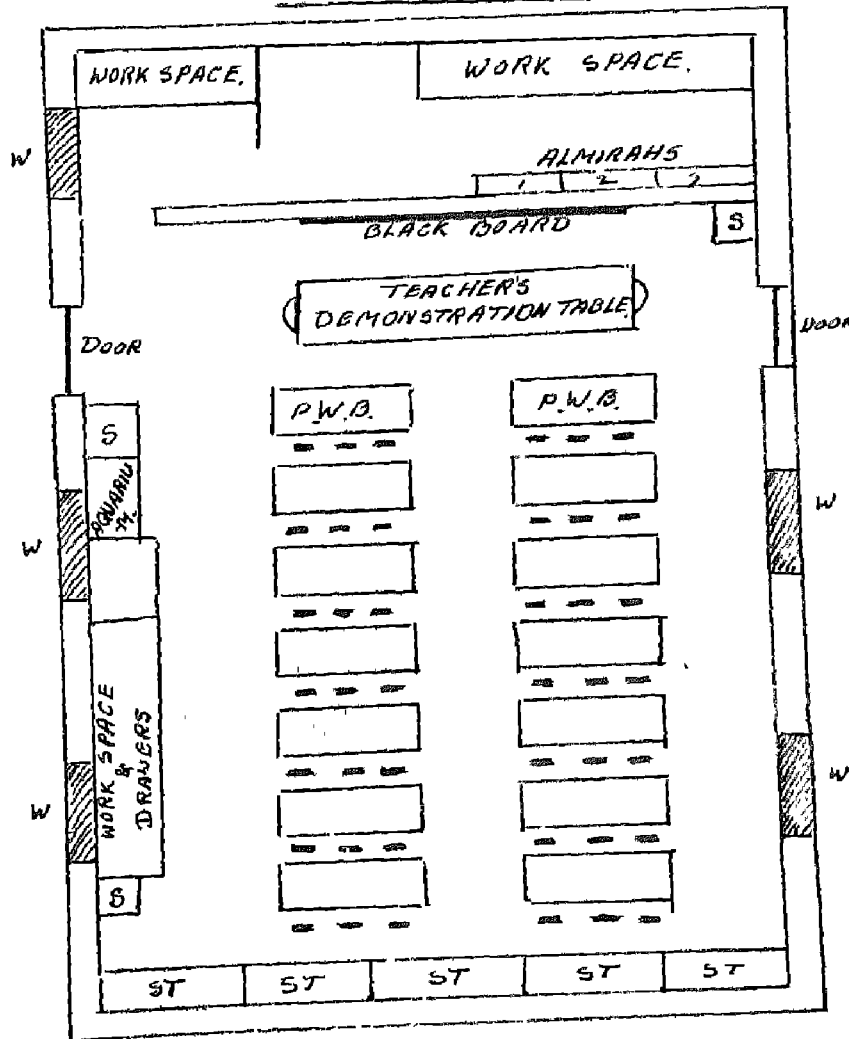
P.W.T.	...	Pupils' Work Table.
D.T.	...	Demonstration table.
R.S.	...	Raised seats.
S.T.	...	Store.
P.R.	...	Preparation Room
U.T.	...	Utility Table.
A.	...	Aquarium
S.	...	Sink.
M.	...	Museum.

Accommodation for 24 pupils

III Plan For A Combined Lecture - demonstration - laboratory Hall for general Science & Chemistry suitable for 42 pupils in a Secondary School

Page - 312

40' x 30'
FOR 42 PUPILS.



Size 40' x 30'

A suggested Plan for the General Science Room for the Secondary Schools to accommodate 42 pupils - Hall for pupils' Practical work and Teacher's Demonstration Lecture.

S	...	Sink
P.W.B.	...	Pupils' Work benches
St.	...	Store
G.	...	Germination Boxes
W.	...	Window

Accommodation for 42 Pupils

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